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Characterization of Contaminated Nuclear Sites, Facilities, and Materials Research and Development

Evaluation Research Corp.
Oak Ridge, TN

Prepared for

Environmental Protection Agency
Washington, DC

Feb 83

U.S. Department of Commerce
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FINAL REPORT

CHARACTERIZATION OF CONTAMINATED NUCLEAR SITES, FACILITIES, AND MATERIALS

(Research and Development)

February 1983

Prepared for:

U.S. Environmental Protection Agency
Washington, D.C.

Prepared by:

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Oak Ridge, TN 37830

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ABSTRACT

The Environmental Protection Agency (EPA) is developing environmental protection standards for evaluating the risks and characterizing problems associated with disposal of radioactive wastes arising from decontamination and decommissioning (D&D) operations. A list of sites authorized to possess radioactive materials for independent research and development (R&D) was compiled. Available information on operations conducted at these sites was used to project the types, characteristics, and volumes of radioactive wastes likely to be generated during their decommissioning. The facilities were divided into three categories according to the operation conducted and the probability of radiological problems arising during D&D.

Category RD-1

62% of the facilities handled primarily sealed radioactive sources and small quantities of unsealed materials. D&D activities should be relatively simple and free from radiological problems. Only small quantities of radioactive waste should be generated. The projected volume of waste from all facilities in this class is on the order of 100 m^3.

Category RD-2

Two hundred fifty-five (35%) of the facilities are involved primarily in the development and production of radioisotopes, research, and labelling of organic compounds. They may have moderate levels of residual contamination and major components will need to be decontaminated and/or removed and handled as radioactive waste. All facilities will generate low-level waste such as cleaning solutions and equipment used during decontamination, but only 50% are expected to require disposal of equipment. The projected volume of waste for facilities requiring equipment disposal is 21-52 m^3. The estimated

volume of waste from all facilities in this class ranges from 3900-8900 m^3.

Category RD-3

Twenty-five (3%) of the facilities handled significant quantities of radionuclides, primarily for the fabrication of sealed sources. These facilities may require major decontamination, including removal of the major laboratory components. The volume of projected waste is 24-64 m^3 at each of the 25 facilities with an estimated total volume of 600-1600 m^3.

The volume of radioactive waste generated by the decontamination and decommissioning of independent research and development institutions is projected to be relatively small (approximately 3500-10500 m^3) through the year 2000. For comparison, in 1980 a total volume of about 90,000 m^3 if low-level waste was generated and disposed at commercial facilities.

1.0 INTRODUCTION

Since the initiation of the Manhattan Project in the early 1940's, several thousand sites across the country have conducted activities using naturally occurring radioactive materials, man-made radioactive materials and/or radiation producing devices. Several hundred sites, and individual facilities at these sites, are no longer used and have been shut down or decontaminated and decommissioned. Eventually, all such sites will need to be decommissioned. Guidelines will be needed to establish procedures for the decontamination and decommissioning (D&D) of all nuclear facilities, including laboratories conducting nuclear research and development activities (non-fuel cycle).

1.1 EPA Program and Objectives

The Nuclear Regulatory Commission (NRC), Department of Energy (DOE), and Environmental Protection Agency (EPA) are all involved in the preparation of procedures and guidelines for decontamination and decommissioning which will assure that nuclear facilities are retired in a manner acceptable to the various regulatory agencies and the general public, and which can be achieved by the nuclear industry. The NRC and agreement states are responsible for licensing independent R&D facilities. The EPA assumes responsibility for assuring public health following decontamination and decommissioning.

The EPA was given a mandate through the Resource Conservation and Recovery Act of 1976 to develop a series of environmental protection standards for evaluating the risks and characterizing problems associated with disposal of radioactive wastes arising from D&D operations. As a basis for development of standards, information is required to describe the approximate number of sites, the operations conducted, and the types of contaminated materials at each site. Technical assessments are required to characterize the problems, evaluate the risks, and examine different decontamination and decommissioning options available and any occupational risk associated with each method. An analysis of techniques for demonstrating compliance, and a review of existing standards and regulations related to decontamination and decommissioning are also

required. In addition, types and volumes of residual radioactive wastes must be projected in order to evaluate D&D options.

1.2 Scope of the Present Project

Independent research and development (R&D) laboratories are one group of facilities which will require decontamination and decommissioning. There are several hundred of these facilities throughout the United States. Volumes and characteristics of radioactive wastes generated from decontamination and decommissioning of these R&D facilities may vary greatly according to the operations conducted at each site.

The purpose of this work effort was to assist the EPA in the characterization of problems associated with decontamination and decommissioning at R&D facilities by compiling a list of R&D facilities in the United States and analyzing generic operations conducted at each to estimate the volume and characteristics of radioactive wastes that will be generated during decontamination and decommissioning. Facilities which may require decontamination have been identified, and estimates have been made of the nature and volume of the radioactive contaminants and radioactive wastes which may result from the decontamination and decommissioning operations.

2.0 METHODOLOGY

2.1 Approach

There are many companies and institutions which conduct independent (not federally supported) research and/or development activities using radioactive materials. The areas of R&D are varied and include radionuclide studies, nuclear chemistry, commercial product testing, and development of new radiopharmaceuticals. A list of these independent R&D facilities was compiled to identify facilities which might require decontamination and decommissioning, and this provides the base for estimating the quantities of radioactive waste that will be generated.

There is no single reference available containing a complete list of these sites and facilities. The number of independent nuclear research and

development operations changes with the creation of new businesses or projects. Many companies engaged in some form of R&D activities use small quantities of radionuclides which are exempt from licensing requirements. This is especially true for companies involved in development of instruments and devices for use in the nuclear industry. A company may be licensed for possession only of exempt quantity radionuclides, however, it is possible that they could be licensed for possession of exempt quantities of a significant number of radionuclides. While it is not feasible to find every company with license-exempt quantities of radionuclides, those identified in our search have been included in this study.

Several different approaches, as described in the following sections, were used to compile the list of institutions conducting independent nuclear research and development activities (Appendix A). Efforts were also made to identify specific R&D activities conducted at the various facilities.

2.2 Literature Review

The resources of the Central Research Library at the Oak Ridge National Laboratory were used extensively in the compilation of information for this report. Data bases maintained by the Information Center Complex (ICC) at the Oak Ridge National Laboratory and the Technical Information Center (TIC) operated by DOE were searched for information describing R&D sites, facilities, and activities. The following keywords were used to identify information sources on facilities, operations, radioactive materials used, and decommissioning plans and activities:

- Research,
- Residual radiation levels,
- Radioactive waste volumes,
- Radioactive materials,
- Nuclear research,
- Decontamination, and
- Decommissioning.

Several documents were found using the keyword "decontamination," but were not applicable to the scope of this project.

A good source of information was found using the keyword "research" (listed under "research-industrial"). The document entitled "Industrial Research Laboratories of the United States, 16th Edition, 1979," contained a list of companies conducting various R&D projects current to 1979. (Ca79) Information was extracted from this report for the following pertinent R&D categories:

- o Accelerators,
- o Atomic physics,
- o Dosimetry,
- o Isotopes,
- o Nuclear chemistry,
- o Nuclear energy,
- o Nuclear instrumentation,
- o Nuclear physics,
- o Nuclear radiations,
- o Radiation physics,
- o Radioactive materials,
- o Scintillation, and
- o Shielding.

Each company identified in this document was contacted to see if they actually handled non-exempt quantities of radionuclides and if contamination problems might occur. In addition, information about R&D activities was obtained for the companies listed. This information was generic in nature, but increased the reliability of our estimates.

Another useful document was found under the keyword "nuclear research." "Nuclear Research Index" (Bu76) lists major nuclear R&D laboratories and activities being conducted throughout the world, current to 1975. Information about companies with retired licenses or completed projects as well as with active projects producing potential residual radioactivity was compiled from this document.

"Technology, Safety, and Costs of Decommissioning Reference Non-Fuel-Cycle Nuclear Facilities" (Mu81) was also found as a result of this search. This publication, prepared for the NRC by Pacific Northwest Laboratory, contains useful information about many aspects of D&D for several different type facilities. This document proved to be a particularly helpful source of information.

2.3 Other Sources of Information

2.3.1 Review of NRC docket files

The Oak Ridge National Laboratory, assisted by the Oak Ridge Operations of ERC, recently conducted an evaluation of terminated licenses isssued by NRC (previously AEC) under the authority of the Code of Federal Regulations, Title 10, Part 30. In addition, ORNL also evaluated similar licenses issued under 10 CFR Parts 40 and 70. (Nu79a, Nu79b, Nu79c) The docket files were examined for information pertaining to radioactive materials licensed at various sites, activity limits and form (e.g. sealed, etc.), types of operations conducted at the site, and special problems. The object of the work was to assist NRC in determining if decontamination was necessary and to identify potential problems at each site. All of these dockets had been entered into data bases at the ICC at ORNL, with individual databases for the Parts 30, 40, and 70 docket files.

These data bases were searched for research and development laboratories during the current project. Those entries found were further examined for types of radioactive materials on-site and other specific information needed for the project.

Additional nuclear byproduct licenses on file with the NRC, current to 1979, were manually searched to locate additional independent R&D facilities. Many companies and institutions which might require D&D activities were not licensed by the NRC because of the Agreement State Program, so it was necessary to contact those states for additional information.

2.3.2 Contacts with State and Territorial Governments

Letters were sent to radiological health or radiation control offices in all fifty (50) states, Puerto Rico, and the District of Columbia in an attempt to acquire further information and add to the list of nuclear R&D companies. Figure 2.1 shows an example of the form letter mailed to each state. Five states and the District of Columbia did not reply, while six others indicated that they were unable to provide the requested information due to legal constraints or limitations in state personnel.

August 18, 1981

<gender> <first> <last>
<where>

Dear <gender> <last>:

Evaluation Research Corporation has a contract with the Environmental Protection Agency to characterize problems that may be encountered in the decontamination and decommissioning of facilities which are or were formerly licensed by the U.S. Nuclear Regulatory Commission or Agreement States, and with registered accelerator facilities. Our interests are restricted to those used to manufacture radiopharmaceuticals and radioisotopes and independent research and development institutions.

If you have a listing of facilities used for the manufacture of radiopharmaceuticals and radioisotopes and of independent research institutions in your State we would appreciate receiving a copy of the list. We are also compiling information on the likely radiological conditions of the sites and facilities. Any sources of information you have or are aware of concerning the types of operations and/or types and quantities of radionuclides authorized for possession, would be very helpful.

The U.S. Bureau of Radiological Health, "Report of State and Local Radiological Health Programs" Fiscal Year 1977, (HEW Pub. No. 78-8034) lists the number of accelerators registered by your state but no information is given as to type or location. Our data base and library searches have provided specific identification for relatively few of the accelerators listed for your State. Again, if information or references are available we would like to receive a copy of the publication or the publication name and number.

If you have any questions with respect to this enquiry please contact me or Ms. Joann Epler (Ph. 615-482-7973). Thank you for your consideration.

Sincerely,

Donald Jacobs
Manager, Oak Ridge Operations

DGJ:mgr

Figure 2.1 Letter to States

Still other states were able to supply only very limited information. Forty-five states, Puerto Rico, and the City of New York provided detailed information.

2.3.3 Contacts with Selected Companies

The scope of nuclear research and development activities varies widely. Some small companies may use only a small amount of radioactive material in one project, while other companies may use several thousand curies in one or many projects. Several companies were selected from the total list of institutions for a more detailed investigation of their R&D activities. A representative sample of small companies, large corporations, and independent scientific laboratories covering a wide variety of operations comprised the inquiry list.

All known sites of a given category (Section 2.5) were compared with a representative site responding to the inquiry. It was not possible to obtain responses from all of the facilities listed, but it is assumed that the sampling method produced representative information.

Information requested from each company included the following items:

- In general, what R&D operations involve the use of nuclear byproduct material, and what is the expected duration of the project(s); or if license has been retired, what operations were conducted?
- What are the major radionuclides and in what quantities are they used?
- Has decommissioning been conducted or is it being planned for any of the facilities and sites?
- What procedures are (were) used for accountability of radioactive materials?
- What procedures are (were) used to prevent or deal with radioactive contamination?

2.4 Assumptions for D&D Considerations

Much of the R&D work conducted at the facilities listed in this report involves the use of sealed radioactive sources or low concentrations of unsealed radioactive materials. Sealed sources exceeding NRC license-exempt quantities can be properly disposed of by burial, following transfer to an authorized recipient meeting criteria listed in 10 CFR 30.41. (Nu79c) Radiological inspections should be conducted at areas where large quantities of sealed sources have been stored and used in order to determine if there has been leakage, especially in cases where regulatory inspections during the operating period indicated items of noncompliance. In the event of leakage of a radioactive material, the affected area may require decontamination.

Some sealed sources contain high levels of radioactivity, and should be removed from the facility for transfer or disposal.

The major concern for decontamination should be placed upon operations where contamination is present due to radioactive materials having a half-life greater than 5 years, where there is a high potential for contamination due to the type of operations performed, and where large quantities of non-sealed radioactive materials have been used. Inspections of sites may be conducted to determine whether full radiological surveys will be required (Le78); full surveys are needed only if there is evidence of extensive contamination. Areas of major concern will include hot cells and the equipment therein, pipes and drains, radiochemical laboratories, and shielding materials.

Initial decontamination procedures for all R&D facilities should include conventional cleaning of all areas where radioactive materials have been handled. Appropriate protective clothing and precautions should be used to reduce potential health risks (ICRP64, ICRP77). Conventional cleaning methods probably will suffice for many of the reported facilities. However, in some instances conventional cleaning methods will not reduce the contamination to acceptable levels; additional procedures including scrubbing, sanding, or covering of contaminated equipment will be required in these cases. Equipment which is covered should be marked, and

precautions should be taken to guard against escape of radioactive materials. Equipment which still does not meet the permissible limits even after covering, can be removed and treated as radioactive waste (ICRP64). Contaminated clothing can be placed in containers and removed for cleaning, chemical treatment, or burial.

Many of the facilities can be reused after decommissioning with only conventional cleaning methods and removal of sealed sources. Other facilities will require temporary closure with restricted access and continuing surveillance.

The Code of Federal Regulations, Title 10, Part 30.70 (Nu79a) specifies permissible concentrations of specific radionuclides for conventional disposal in liquid and solid forms. Before disposing of radioactive materials in conventional ways, activity levels must comply with these permissible concentrations. Acceptable quantities of radionuclides in liquid form can be discharged to process wastewater, where concentrations will be further reduced by dilution. Acceptable quantities in solid form can also be disposed of by conventional means (e.g., landfill).

It is important to minimize dose to workers and the general population in the vicinity of a facility. A precise quantitative relationship between levels of radioactivity on surfaces and the resulting radiation doses to personnel or population groups does not exist; rather, the dose rate depends upon the nature and form of the radionuclides present. Much of the "free" and "ambient" radioactive materials (e.g. dust) should be removed during decontamination operations. The major contributor to the radiation dose rate should then be "fixed" radioactive material. The Division of Fuel Cycle and Material Safety of the NRC has issued guidelines for decontamination for these type facilities and along with this has listed acceptable surface (fixed) contamination levels. (Nu80)

The International Commission on Radiological Protection (ICRP) has recommended a radiation dose limit of 0.5 rem (500 mrem) per year in consideration of somatic risk to members of the general public. (ICRP77)

For occupational exposures, a limit of 5 rem per year has been recommended. "Standards and Guidelines Pertinent to the Development of Decommissioning Criteria for Sites Contaminated with Radioactive Material" (Di78) gives additional information on criteria for decommissioning.

The final criteria for decommissioning a nuclear facility should establish an exposure rate at the facility which would not give rise to the annual limit of more than 500 mrem when combined with any other radiation exposures in the area including natural background. Further efforts should be made to reduce the exposure rate to the lowest extent practicable.

2.5 Categorization of Facilities

For the purpose of this report, research and development facilities have been divided into three categories according to the activities conducted and the likely severity of decontamination and decommissioning problems:

RD-1) those facilities (62% of the facilities surveyed) where operations involve the use primarily of sealed sources and/or low quantities of unsealed radioactive materials which will result in minimal D&D requirements involving the disposal of small quantities of radioactive materials or transferring licensed sealed sources to an authorized recipient;

RD-2) those facilities (35% of total) which use high-activity sealed sources for irradiation or larger quantities (generally 500 mCi - several Curies) of unsealed radioactive materials for development of radioisotopic compounds or organic tagging; these activities may result in moderate facility contamination with some decontamination and/or removal of components necessary; and

RD-3) those facilities (3% of total) which use large curie quantities of radionuclides, some of which are long-lived, in unsealed form (tritium, carbon-14, and other byproducts) for radioisotope studies and development; these facilities may require major laboratory decontamination with D&D options including removal of the major laboratory components (e.g. hoods).

3.0 DESCRIPTION OF FACILITIES

3.1 Facility Characterization

3.1.1. Location

The list of facilities in Appendix A was inspected to determine the number of facilities in each state and NRC region, and a comparison was made of category types in each region. Information was found on independent research and development facilities within the scope of this project in thirty-six states, Puerto Rico, and the District of Columbia, although there are probably some of the RD-1 category facilities in every state.

Table 3.1 lists the number of facilities identified in each state. A tabulation of R&D facilities identified in each NRC region is presented in Table 3.2. Figure 3.1 is a map of the United States showing regions with the number of facilities in each state.

The State of New York has the greatest number of reported R&D facilities with 137; fifty-nine of these have been identified in categories RD-2 or RD-3. Massachusetts has 79 facilities, New Jersey has 72 facilities, and Illinois has 61 facilities. Only 28% of the facilities in those three states are classified in categories RD-2 or RD-3, but these may contribute significant volumes of radioactive wastes at decommissioning.

The majority of the total facilities, 412 of the total 723, are located in NRC Region 1; of these, 36% are classified in category RD-2 or RD-3. Only 10 facilities in NRC's southern region (Region 2) are classified in category RD-2, with no facilities in category RD-3.

3.1.2 Use

Each of the facilities in Appendix A has been assigned to one of the three categories mentioned in Section 2.5. In those cases where individual activities within a facility may fall within different

Table 3.1
Number of R&D Facilities Reported per State

State	Category 1	2	3	Total
*Alabama	0	1	0	1
Alaska	-	-	-	0
*Arizona	1	0	0	1
*Arkansas	-	-	-	0
*California	14	10	2	26
*Colorado	1	2	0	3
Connecticut	20	6	0	26
Deleware	1	2	0	3
D.C.	2	1	0	3
*Florida	1	3	0	4
*Georgia	1	1	0	2
Hawaii	3	0	0	3
*Idaho	-	-	-	0
Illinois	45	14	2	61
Indiana	7	7	0	14
Iowa	-	-	-	0
*Kansas	-	-	-	0
*Kentucky	-	-	-	0
*Louisiana	0	2	0	2
Maine	3	2	0	5
*Maryland	1	2	2	5
Massachusetts	55	21	3	79
Michigan	18	13	2	33
Minnesota	4	2	1	7
*Mississippi	-	-	-	0
Missouri	8	6	3	17
Montana	-	-	-	0
*Nebraska	-	-	-	0
*Nevada	-	-	-	0
*New Hampshire	-	-	-	0
New Jersey	48	22	2	72
New Mexico	-	-	-	0
*New York	78	57	2	137
*North Carolina	0	1	0	1
*North Dakota	-	-	-	0
Ohio	36	19	2	57
Oklahoma	4	0	0	4
*Oregon	0	1	0	1
Pennsylvania	41	22	4	67
Puerto Rico	1	0	0	1
*Rhode Island	13	3	0	16
*South Carolina	-	-	-	0
South Dakota	-	-	-	0
*Tennessee	1	1	0	2

Table 3.1 (Ctd.)

State	Category 1	2	3	Total
*Texas	6	14	0	20
Utah	6	1	0	7
Vermont	-	-	-	0
Virginia	9	4	0	13
*Washington	1	2	0	3
West Virginia	1	0	0	1
Wisconsin	14	10	0	24
Wyoming	0	1	0	1
Total	443	255	25	723

*NRC Agreement State

Table 3.2
No. of R&D Facilities Reported in Each NRC Region

	Category			Total
	1	2	3	
NRC Region 1				
Connecticut	20	6	0	26
Delaware	1	2	0	3
District of Columbia	2	1	0	3
Maine	3	2	0	5
*Maryland	1	2	2	5
Massachusetts	55	21	3	79
*New Hampshire	-	-	-	0
New Jersey	48	22	2	72
*New York	78	57	2	137
Pennsylvania	41	22	4	67
*Rhode Island	13	3	0	16
Vermont	-	-	-	0
Region Total	262	138	13	412
NRC Region 2				
*Alabama	0	1	0	1
*Florida	1	3	0	4
*Georgia	1	1	0	2
*Kentucky	-	-	-	0
*Mississippi	-	-	-	0
*North Carolina	0	1	0	1
*South Carolina	-	-	-	0
*Tennessee	1	1	0	2
Virginia	9	4	0	13
West Virginia	1	0	0	1
Puerto Rico	1	0	0	1
Region Total	14	10	0	25
NRC Region 3				
Illinois	45	14	2	61
Indiana	7	7	0	14
Iowa	-	-	-	0
Michigan	18	13	2	33
Minnesota	4	2	1	7
Missouri	8	6	3	17
Ohio	36	19	2	57
Wisconsin	14	10	0	24
Region Total	132	71	10	212

Table 3.2 (Ctd.)

	Category			Total
	1	2	3	
NRC Region 4				
*Arkansas	-	-	-	0
*Colorado	1	2	0	3
*Kansas	-	-	-	0
*Idaho	-	-	-	0
*Louisiana	0	2	0	2
Montana	-	-	-	0
*Nebraska	-	-	-	0
New Mexico	-	-	-	0
*North Dakota	-	-	-	0
Oklahoma	4	0	0	4
South Dakota	-	-	-	0
*Texas	6	14	0	20
Utah	6	1	0	7
Wyoming	-	1	-	1
Region Total	17	20	0	38
NRC Region 5				
Alaska	-	-	-	0
*Arizona	1	0	0	1
*California	14	10	2	26
Hawaii	3	1	0	3
*Nevada	-	-	-	0
*Oregon	0	1	0	1
*Washington	1	2	0	3
Region Total	18	15	2	34
U.S. Total	443	255	25	723

*NRC Agreement State

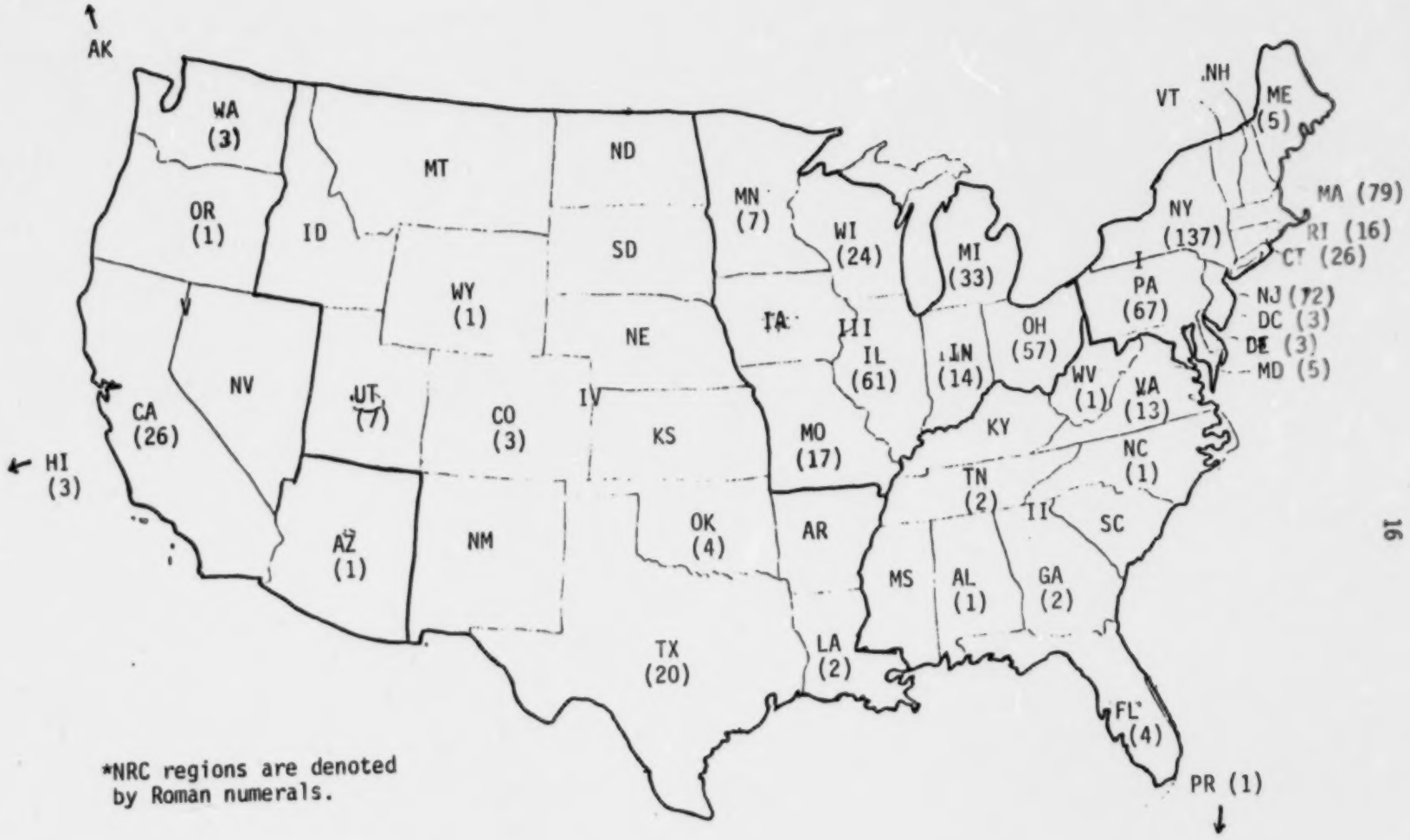

Figure 3.1 Map of R&D Distribution in the U.S.

categories, the overall facility is assigned to the most restrictive category applicable.

The types of activities conducted at the three different categories of facilities overlaps among the categories, especially RD-2 and RD-3. Generally, though, R&D activities at RD-1 facilities are involved with the development of nuclear instrumentation or placement of sealed sources in commercial and industrial operations. Some RD-1 facilities use low concentrations of non-sealed radioactive materials, usually short-lived. (Nu81) RD-2 facilities generally use sealed sources for irradiation and non-sealed materials for radioactively tagging organic compounds. RD-3 facilities develop new radioisotopic compounds and possess large volumes of radioactive materials, often including long-lived radioisotopes (e.g. ^{3}H and ^{14}C).

The first category contains 62% of the facilities examined in this study. The second category contains 35% of the total facilities. Only 3% of the facilities examined in this study are projected to fall within Category RD-3 and to be of radiological significance.

3.1.3 Operating Lifetime

Most of the companies identified in this report eventually market specific products developed as a result of research and development. The duration of a project is usually based upon the salability of the product, continuing efforts to enhance the product, and least of all, radiological contamination of the laboratory and/or equipment. Decommissioning must be planned at the end of the project lifetime or after certain equipment has become highly contaminated. For most of the facilities in the report, some D&D operations will be needed after 10 years of usage. Major laboratory components such as hot cells and fume hoods, will need to be replaced at about half of the category RD-2 and all of the RD-3 facilities, even if the total facility is not decommissioned.

The list of facilities received from the State of New York contained license expiration dates and in some instances specified whether or not an expired license had been renewed. Of the 112 facilities on this

list, 25% of the licenses expired from 1977-1980 and were not renewed. Twenty percent expired from January 1980 to June 1981. Another 20% were to expire after June 1981 but some of these licenses may have been renewed. (The list is only current to June 1981). Over 30% of the licenses were to expire in 1982.

This suggests that about 20% of the facilities will require some decontamination and possibly decommissioning every year (i.e., those facilities for which expired licenses are not renewed). At the same time, new facilities will be put into use, but the total of these cannot be accurately projected. In addition, individual pieces of equipment will require replacement and decommissioning on a periodic basis, even in facilities which continue to conduct operations under a current license. For this study, all of the facilities identified are assumed to require some form of decommissioning by the year 2000.

3.2 Waste Characterization

3.2.1 Radiological Characteristics

The main constituents of the radioactive waste generated from these facilities will be nuclear byproduct materials (atomic numbers 3-83) and tritium. Table 3.3 lists commonly used radionuclides and some of their properties. These radionuclides will comprise the majority of radioactive waste for facilities in categories RD-1 and RD-2. The quantities of radionuclides possessed in category RD-1 facilities are usually small and often encapsulated; most non-encapsulated nuclides used at these facilities have short half-lives. (Nu81)

Much of the residual radioactivity in categories RD-2 and RD-3 facilities will result from non-encapsulated radioactive materials. This residual radioactivity will result primarily from contamination, although a very small percentage will result from activation at certain sites. Table 3.4 lists R&D facilities licensed for radioactive activation of materials.

Radionuclides are usually prepared and stored as salts, usually in HCl, HNO_3, normal saline solution, or in metal complexes. ^{131}I and ^{135}I

Table 3.3
Radionuclides Commonly Used in Independent R&D Operations
(Mu81, Ko81)

Nuclide	Half-life	Average Energy Beta (MeV)	Average Energy Gamma (MeV)
^{3}H	12.28 yr	0.0057	--
^{14}C	5730 yr	0.0495	--
^{32}P	14.29 days	0.695	--
^{35}S	87.44 days	0.0488	--
^{60}Co	5.27 yr	0.0958	2.51
^{90}Sr	28.6 yr	0.196	--
^{90}Y[a]	64.1 hr	0.935	--
^{125}I	60.14 days	0.0172	0.0415
^{131}I	8.04 days	0.190	0.381
^{137}Cs	30.17 yr	0.171	--
^{137m}Ba[b]	2.55 min	0.0637	0.598

[a] Produced from decay of ^{90}Sr.
[b] Produced from decay of ^{137}Cs.

Table 3.4
R&D Companies Licensed for Operation of Activation Facilities

Company	Location
Allied Chemical Corp.	General Chemical Division Morristown, NJ
Bartol Research Foundation	Nuclear Physics Department Swarthmore, PA
Curtiss-Wright Corp.	Clifton, NJ
Diamond Alkali Co.	Painesville, OH
E.I. DuPont de Nemours & Co., Inc.	Penn Grove, NJ
General Dynamics Corp.	San Diego, CA
Johns-Manville Research Center	Manville, NJ
Lockheed Aircraft Corp.	Palo Alto, CA
Martin Co.	Middle River, MD

are prepared as hydroxide solutions or as AgI. The sealed sources in use usually have long half-lives (>5 years). Quantities of radioactive materials range from a few picocuries (category RD-1) to several curies, but usually are 100 mCi or less because of license restrictions. (Mu81) The major nuclides commonly used in sealed sources with relatively long half-lives include ^{60}Co, ^{137}Cs, and ^{90}Sr. Facilities which conduct gamma irradiation generally use ^{60}Co or ^{137}Cs sources with radioactivity levels in the kilocurie range. Tritium (^{3}H) and ^{14}C are often used at RD-2 and RD-3 facilities in an non-encapsulated form. Other radionuclides commonly used in R&D activities include ^{125}I, ^{55}Fe, ^{35}S, ^{36}Cl, ^{26}Al, and ^{55}Cr. Special nuclear materials, e.g. ^{235}U, are licensed for use at many category RD-3 facilities.

3.2.2 Physical Characteristics

In category RD-2 and RD-3 facilities, fume hoods, glove boxes, bench tops, ductwork and drains will need to be decontaminated. In addition, walls, floors, vaults and other storage areas may also present a radiological problem upon facility decommissioning. Hot cells with manipulators are often used at R&D facilities for handling high energy gamma emitters in large curie quantities. Hot cells and any associated equipment may have to be decontaminated, stored, or mothballed, or removed and handled as radioactive waste.

Modern fume hoods are typically constructed of steel, with interior surfaces of stainless steel, aluminum, or masonite. Other models are constructed of steel and asbestos. Exhaust ductwork is constructed of stainless steel, glass fiber, asbestos pipe, iron, aluminum, or sheet metal, with several coats of corrosion-resistant plastic-base paint applied to surfaces made of iron or aluminum. Fume hoods used in work involving radioactivity usually vent exhaust through roughing and high-efficiency particulate air (HEPA) filters located in the exhaust duct immediately above the hood.

Glove boxes are used for operations which present a significant potential for radioactive contamination or when toxic dust or vapors are present. A glove box provides positive containment while performing manual

operations using hazardous material. These enclosures are shielded with lead or concrete when their intended use involves high energy, penetrating radiation (e.g. ^{60}Co). Hot cells with manipulators are often required for handling large quantities of penetrating radiation (e.g. several curies of ^{60}Co). The walls in a hot cell are typically constructed of lead or concrete bricks. The walls are sometimes lined with removable material, e.g. paper, which would aid in decontamination.

Some facilities have used on-site burial for disposal of low-level waste, usually byproduct materials. These should be considered on a case by case basis with an analysis of the nature and volume of the disposed materials. Long-lived radioactive materials could be of concern, especially if migration from the disposal medium (e.g. trench) has occurred.

3.2.3 Chemical Characteristics

Solutions used to remove surface contamination generally consist of acids (e.g. HCl) or complexing agents (e.g. EDTA). The chemical form may be an important factor affecting the transport of radioactive materials in the environment following disposal. In most cases it is desirable to neutralize acids prior to disposal.

Some of the waste materials may exhibit chemical toxicity in addition to their radioactive characteristics, although characterization of these wastes is uncertain. Generally, considerations should be given to acids and hydroxides used as reagents, organic compounds used in labeling studies, asbestos, and other chemically toxic materials.

3.2.4 Handling considerations

Occupational exposure must be considered in planning D&D operations. Exposures should be kept as low as reasonably achievable (ALARA). Workers will be needed for radiation surveys, decontamination, equipment removal and transportation to other locations.

Dust and non-fixed particles will be a potential source of radiation exposure, especially when cutting contaminated concrete. Respirators should be worn along with other safety equipment when the situation dictates. All radioactive shipments should be packaged according to the Code of Federal Regulations, Title 49 and any other applicable regulations.

In addition, some fume hoods may contain asbestos, which is a potential health hazard. Handling procedures should be designed to minimize exposures to asbestos dust.

4.0 GENERIC FACILITY DESCRIPTIONS

4.1 Activities

Descriptions of typical operations at each of the three categories of facilities in this report are given below. A wide range of activities is conducted at each type, especially in categories RD-1 and RD-2.

In most cases, the operating lifetime of the project is not determined by the final results of an experiment, but to the improvement of products and company business policies. Thus, the lifespan of equipment and operations using radioactive materials is highly variable.

4.1.1 Generic Facility - RD-1

Activities conducted at facilities categorized as RD-1 primarily involve the use of sealed radioactive sources, both in exempt and non-exempt quantities, and small quantities of unsealed materials. (Nu81) A typical activity would be the placement of a sealed source (e.g. ^{63}Ni) in a smoke detector being tested and developed for industrial use. One such company uses 5 uCi sources for this purpose. There are procedures established for logging the movement of sources from their storage place, usually a locker or vault, to other areas within or away from the facility. Radioactivity in the work area is monitored on a regular basis to detect possible contamination. If discernible levels above background are detected, appropriate steps are taken to remove the contamination. Although each individual source may contain only a small quantity of

radioactive materials, there may be several hundred sources at a site, resulting in a significant total.

Some activities involve only a limited number of small radioactive sources at a particular site. They are generally in license-exempt quantities and typically used as calibration sources (e.g. ^{60}Co or ^{154}Eu) or in gas chromatography (where ^{63}Ni is often a source material for an electron capture detector).

Licensed sealed sources must be leak tested every six months. Companies with license-exempt quantities of sealed sources sometimes test for leakage on a non-regular basis.

4.1.2 Generic Facility - RD-2

Facilities categorized as RD-2 are usually involved in development and production of radioisotopes (including sources), biomedical research, or the labelling of organic compounds.

The generic facility uses radiochemicals in the development of new or improved analytical procedures. Activities using radioactive materials are generally conducted in vented laboratory hoods, glove boxes, and hot cells, which may become contaminated. Alternatively, the facility might use a pool irradiator containing a sealed source of several thousand curies of ^{60}Co. The pool would not pose a contamination problem unless leakage from the source had occurred; the pool and the source will have been tested routinely for leakage during active operations.

4.1.3 Generic Facility - RD-3

RD-3 facilities use large quantities of radionuclides, some of which are encapsulated. The fabrication of sealed sources and radioisotopes is the primary activity conducted at these facilities.

The generic facility is involved with the development and improvement of radioisotopes and studies of metabolism of labeled organic components. Most work is done in glove boxes and hot cells. Pool

irradiation devices also may be present. Material accountability procedures are used, but some radioactive contamination may occur.

4.2 Waste Characteristics

4.2.1 Generic Facility RD-1

At most of the RD-1 facilities the only items likely to be contaminated are cabinets, vaults, and refrigerators used to store the radioactive sources. In a few cases bench tops may be contaminated from the use of low-level unsealed radioactive materials, but the half-lives of these materials are usually short. The entire facility and components ordinarily can be reused. The sealed sources can be used in other operations, transferred to another facility, or sold.

4.2.2 Generic Facility RD-2

Activities using radioactive material at RD-2 facilities are generally conducted in vented laboratory hoods, which may become contaminated. Glove boxes and hot cells are sometimes used and may need to be decontaminated or removed for disposal if they are contaminated. The laboratory surfaces (e.g. walls, floors, and ceilings) can be decontaminated to levels for unrestricted use (Mu81) with the possible exception of floor tiles. Ventilation ductwork and air filters should be disposed of, along with sink and drain systems, if contaminated. Upon decommissioning, the shielding materials should be inspected for contamination. (Nu81) No waste should result from decommissioning pool irradiators, except for the radioactive source.

4.2.3 Generic Facility RD-3

Pipes, drains, glove boxes, hot cells and hoods are likely to require decontamination at RD-3 facilities. All hoods and glove boxes not used for product packaging, or non-radiochemical operations, will be contaminated and will probably require disposal. However, those used for handling short half-lived radionuclides can probably be reused if the hoods are steam sprayed, chemically treated, or stored temporarily to allow contamination to decay to levels acceptable for unrestricted use. Laboratories which are used to handle high energy, penetrating gamma

emitters usually have 1 or 2 hot cells that can be decontaminated to some degree and disposed of as radioactive waste. The lead bricks used for shielding can be reused for similar purposes. Sinks, pipes, and drains should be disassembled, packaged, and discarded if they cannot be decontaminated to levels acceptable for unrestricted use. The laboratory surfaces can be decontaminated to acceptable contamination levels at most of the facilities. Tiles and linoleum may have to be disposed of as radioactive waste. Any sealed sources should be handled as radioactive or transferred to other operations.

4.3 D&D Alternatives

Procedures for decommissioning and any required decontamination will depend upon the R&D operations conducted at each facility. Many of the sites surveyed use only very small amounts of radionuclides in sealed sources (category RD-1). D&D operations for these RD-1 sites and facilities would consist primarily of:

1) Accountability for all sources;

2) Certification that sealed sources have been disposed of or returned to the supplier;

3) Radiation survey to determine if sources had leaked;

4) Conventional cleaning of any areas which are found to be contaminated; and

5) Removal of equipment and facilities that cannot be adequately decontaminated (minimal for RD-1 facilities).

The facility then would be ready for unrestricted use. The economic, environmental, and radiological impacts of decommissioning category RD-1 facilities are likely to be relatively insignificant in comparison to the RD-2 and RD-3 facilities.

D&D alternatives for sites and facilities (RD-2 and RD-3) which use larger quantities of radioactive materials, many of which are unencapsulated, involve a more rigorous approach. In addition to conventional cleaning, the alternatives include:

1) Decontamination,

2) Mothballing (temporary storage),

3) Entombment, and/or

4) Dismantling, with storage of certain potentially reuseable components, and disposal of all radioactive waste materials.

Mothballing involves only a general clean-up around the facility. All loose contaminated materials are packaged for disposal. Entrances to the building(s) are blocked to prohibit access. Entombment is similar to mothballing except that all entrances are sealed with concrete. (Op79, Nu81) Accordingly, mothballing and entombment do not generate any significant volume of radioactive waste. Temporary storage is an acceptable method for RD-2 facilities, except where long-lived isotopes (^{3}H, ^{14}C, ^{137}Cs, and ^{60}Co) were used in large, uncontained quantities. Where contamination levels are low, conventional cleaning methods may suffice. Laboratory equipment can be sprayed to stabilize surface contamination. If needed, hoods, glove boxes, and bench-top hot cells can be dismantled with smaller parts being stored inside larger ones to reduce waste volumes. These parts can be transported to a low-level burial facility for disposal. No facilities are expected to require entombment. (Mu81) However, the most effective D&D method for pool irradiators where the tank has become contaminated by induced activity or by leakage from the sealed source may be to remove the sealed sources, drain the tank and then fill it with concrete.

5.0 SITE-SPECIFIC ISSUES

The data bases containing information from the NRC docket files were examined for possible site-specific problems, including on-site burial and contamination. These docket files have useful information concerning potential problems with D&D operations at R&D facilities.

5.1 On-Site Disposal

Most institutions and companies presently use commercial radiological waste disposal services for the disposal of their contaminated waste. However, in the 1950's and 1960's, some laboratories disposed of wastes by

on-site burial. On-site disposal may be an important consideration when planning decommissioning. These sites should be examined on an individual basis to determine the actual type and amount of materials in the waste (i.e. what is the potential residual level of radioactivity) and current conditions. In many cases where immediate reuse of the facility is not desired, it may be best to leave the waste in its present disposal site. From the docket file search, fifteen R&D facilities were identified which used on-site disposal of radioactive waste.

Aerojet General Corporation disposed of radiological waste consisting primarily of ^{60}Co, ^{90}Sr, ^{42}K, ^{46}Sc, ^{14}C and other byproduct material by on-site burial at its Sacramento site. ^{90}Sr and ^{14}C could still exist at significant levels.

Isotopes Specialties Co., Burbank, CA disposed of ^{3}H and other byproduct materials by on-site burial. Considering that tritium has a 12-year half-life, it might still present a potential for exposure if containment was breached.

Keystone Chemurgic Corporation, Bethlehem, Pennsylvania, disposed of mCi amounts of radioactive materials by on-site burial.

Allied Chemical Corporation in Morristown, New Jesey stored byproduct materials for at least 2 years and then buried them in isolated plots.

American Cyanimid, Pearl River, New York, incinerated radioactive waste, mostly byproduct materials, and then buried the ashes.

The General Dynamics (General Atomic Division) site in Freeport, Texas, also disposed of radiological waste by burial. This particular facility was licensed for both mCi and Ci quantities of byproduct materials.

Mallinckrodt Nuclear Corporation (near St. Louis) has in the past disposed of liquid wastes into on-site streams. Some settling of suspended

solids has probably taken place, but no estimates of activities or concentrations are available.

ACF Industries, located in the District of Columbia, disposed of ^{90}Sr and byproduct materials by on-site burial.

Additional facilities with on-site disposal were identified in Texas, Michigan, Indiana and Hawaii.

5.2 Radiological Contamination

There have been many instances of laboratories being contaminated to a small degree. Most of this contamination was readily removed. There have also been a few facilities contaminated very heavily. An examination of the NRC docket files discussed earlier revealed that the Budd Co. in Philadelphia had many problems of contamination and overexposure. Much of the contamination was attributed to leakage from radiography sources, some of which contained ^{90}Sr.

Nuclear Consultants, Inc., St. Louis, MO, had at least one incident of very extensive contamination involving Ci quantities of source material. ACF Industries showed records of contamination as well as the Martin-Marietta Corporation in Middle River, MD.

6.0 SUMMARY AND CONCLUSIONS

This section presents estimated volumes of radioactive waste which will result during decommissioning of independent research and development institutions. The estimates are generic in nature. A general summary of the information presented earlier is also given.

6.1 Estimates of Waste Volumes

There should not be any significant radioactive waste arising from the decommissioning of category RD-1 facilities. These facilities should be available for immediate and unrestricted reuse after removal of sealed sources and cleaning of benchtops and floors. In some instances small quantities of unsealed materials will need to be disposed and this can be

accomplished through normal procedures of non-radioactive waste disposal. However, it is possible that small volumes of radioactive waste could result from D&D at a few of these facilities. It is assumed that each facility in this category will generate one 208 liter (55 gal) drum of miscellaneous residue, consisting primarily of cleaning materials; this would amount to a total of only about 100 m^3 from all RD-1 facilities in the United States.

Category RD-2 facilities will require more careful consideration. Each facility should be examined on an individual basis. Many of these facilities use several different long-lived isotopes, and some have pool irradiators on-site. It is estimated that temporary mothballing (storage) and periodic radiation surveys will be sufficient for many of these facilities. In this analysis, it is assumed that approximately 50% of category RD-2 facilities will not generate significant quantities of radioactive waste other than that resulting from conventional cleaning and decontamination.

The remaining 50% of category RD-2 facilities are assumed to generate significant radioactive waste. Floor and ceiling areas requiring cleaning in RD-2 facilities will range from 48-120 m^2 in each facility and wall areas to be cleaned will be 84-132 m^2. (Mu81) These surface areas will not need to be removed and disposed, with the possible exception of floor tiles. If the tiles are removed, the volume would be about 0.4 m^3 (two 208 liter drums). There will be an average of 4 fume hoods at each facility to be cleaned, painted, and/or disposed of. The waste volume for each hood is about 4 m^3. Generally, one of these hoods is routinely used for the hottest operations. Assuming that up to 4 hoods will be disposed of, the volume of waste from hoods is 4-16 m^3 per facility. It is also assumed that most of these facilities would not have more than 1 or 2 glove boxes and 0 to 2 hot cells (where radioisotopes such as ^{137}Cs and ^{60}Co were used in uncontained form). Glove box volumes will average about 1 m^3 each while hot cells will average 1.5 m^3. Lab bench areas will range from 3 to 16 m^2 (x 1 m high). The volume of bench areas not decontaminated to levels of unrestricted use will range from 0 - 6 m^3, assuming that the entire bench is packaged and disposed of. Smaller items to be discarded can be packaged

in the bench. It is assumed that there is only one sink and drain system in a RD-2 laboratory. The sink can be decontaminated in most cases, but if it is disposed of, the volume will be about 1 m^3. The roughing and HEPA filters will require disposal and will range from 3 to 5 m^3 in volume. The largest single contributor to the waste volume will be sprays and foams applied to surfaces for decontamination. These will range from 12 to 18 m^3 at each of the 50% of RD-2 facilities requiring extensive decontamination. At the other 50%, the range will be 2 to 18 m^3 of waste per facility, depending upon the amount of contaminated equipment requiring cleaning.

Additional estimates of potential waste volumes are given in Table 6.1. (Mu81, Nu81) Estimates of volume per individual item have been provided for certain laboratory components (e.g. hoods). These estimates are based on the assumed volume of components at a generic facility, although actual volumes will fluctuate from facility to facility.

The total volume of radioactive waste generated at each of 50% of these RD-2 facilities is estimated to be 21 - 52 m^3. Murphy has calculated that 35 m^3 of contaminated waste would be generated as a result of decommissioning a reference facililty of this type. (Mu81) If the facilities are placed in temporary storage then the actual volumes should be less than these estimates, because short-lived nuclides will decay.

Category RD-3 facilities present more serious problems. Conventional cleaning and disposal of contaminated equipment may be the best alternative for this category. The costs and occupational exposures are higher than those for temporary mothballing, but, after decommissioning, periodic monitoring will not be required and the facility can be released for other uses. It is assumed that significant volumes of waste will be generated during decommissioning at nearly 100% of the RD-3 facilities. If the decommissioning is delayed for some period of time, the volumes of radioactive waste may be considerably reduced. However, the total volumes of radioactive waste from these facilities is quite small compared to wastes from decommissioning of other types of facilities (e.g. accelerators, reactors).

Table 6.1

Estimates of Volumes of Radioactive Waste Generated During Decommissioning of a Typical Category RD-2 Facility[a] (Mu81, Nu81)

Component	Volume (m^3)	Range of Contamination level (dpm/100 cm^2)	Residual Contamination Before Decommissioning (Curies)
Floors	0 - .4	$<5 \times 10^2$ to 2×10^4	4×10^{-6}
Ceilings	0	$<5 \times 10^2$ to 2×10^4	4×10^{-6}
Walls	0	$<5 \times 10^2$ to 1×10^4	7×10^{-6}
Bench Tops	0 - 6	$<5 \times 10^2$ to 1×10^4	8×10^{-7}
Hoods	4 - 16 (4)[b]	$<1 \times 10^4$ to 1×10^5	9×10^{-5}
Glove Boxes	0 - 2 (1)[c]	$<1 \times 10^6$ to 1×10^7	1×10^{-4}
Hot Cells	0 - 1.5	$>1 \times 10^{10}$	4×10^2
Sink/Drains	0 - 1	1×10^4 to 5×10^4	5×10^{-5}
Ventilation Ductwork	3 - 5	2×10^2 to 1×10^5	4×10^{-5}
Cleaning Agents	12 - 18		
Auxiliary:			
Lead Vault	1	$<2 \times 10^4$ to 2×10^5	--
Refrigerator	0.6	$<1 \times 10^3$ to 5×10^4	--
Animal Cages	0	$<1 \times 10^3$ to 5×10^4	--
		$<1 \times 10^3$ to 5×10^4	--
Misc.	0.4		
TOTAL	21 - 52		

[a] Only 50% of RD-2 facilities are assumed to require disposal of these materials.

[b] Parenthetical values indicate the volume of a single unit of contaminated equipment.

[c] Assumes sectioning of glove box.

All laboratory equipment including laboratory benches, hot cells, hoods and ventilation systems will be removed. Small equipment, e.g. centrifuges, can be packaged inside larger pieces. Room surfaces should be washed prior to and after the removal of equipment. Some of the hoods, glove boxes, and hot cells can be decontaminated to the point that they can be reused at other nuclear facilities, although no attempt has been made to identify receivers of these components and other wastes. (Nu81) Table 6.2 lists the estimated ranges for wastes associated with each facility. There is a range of 1-3 sink and drain units in these laboratories giving rise to 1 to 3 m^3 of waste. The volumes for hot cells range from 0 to 3 m^3. Other volume estimates are the same as for RD-2 facilities, except for the decontamination agents and solid trash which will range from 13-21 m^3. The miscellaneous value in Table 6.2 represents routine operational waste which may be left at the site; the volumes of such waste will vary among the RD-3 facilities.

The volume of radioactive waste resulting from D&D at RD-3 facilities is estimated to be 24-64 m^3 per facility. These estimates are only approximate, and individual facilities and components may deviate significantly from these estimates. In fact, some facilities could be an order of magnitude higher than the average. Contaminated landscapes (e.g., on-site radioactive waste disposal areas) may add to the volume, and could more than double the volume of D&D waste generated at a facility. There may also be some contaminated sewage ponds at some of these sites, but mothballing should suffice for these, even if the rest of the facility is reused. Some facilities will be broader in scope and may have multiple laboratories to be decommissioned. The total number of laboratories at a facility can be multiplied by the estimates in Tables 6.1 and 6.2 in order to derive an estimated volume for that facility.

Table 6.3 lists the total estimated waste volumes for the five NRC regions and for each facility category. These values were derived by using the extreme values of the ranges given in Tables 6.1 and 6.2. Only 50% of category RD-2 facilities are assumed to require disposal of equipment, while the other 50% are assumed to be decontaminated sufficiently by other methods; however the decontamination wastes for all facilities have been

Table 6.2
Estimates of Volumes of Radioactive Waste Generated
During Decommissioning of a Typical
Category RD-3 Facility (Mu81)

Component	Volume (m^3)	Range of Contamination level (dpm/100 cm^2)	Residual Contamination Before Decommissioning (Total Curies)
Floors	0-0.4	1×10^2 to 5×10^4	3×10^{-7} - 3×10^{-5}
Ceilings	0	1×10^2 to 1×10^5	6×10^{-8} - 3×10^{-5}
Walls	0	1×10^2 to 1×10^5	2×10^{-7} - 3×10^{-5}
Bench tops	0-9 (3)[a]	1×10^2 to 5×10^4	4×10^{-9} - 3×10^{-6}
Primary Hood	4	$<1 \times 10^5$ to 2×10^9	3×10^{-6} - 3×10^{0}
Other Hoods	0-12 (4)	$<1 \times 10^4$ to 1×10^5	--
Glove Boxes	1-4 (1)	2×10^6 to 2×10^{11}	5×10^{-4} - 6×10^{1}
Hot Cells	0.0-3 (1.5)	2×10^{10} to 2×10^{12}	4×10^2
Sink/Drains	0-3 (1)	1×10^2 to 5×10^4	5×10^{-5}
Ventilation Ductwork	3-5	2×10^2 to 1×10^5	2×10^{-7} - 1×10^{-4}
Cleaning Agents	13-21		
Auxiliary:			
Lead Vault	1	$<2 \times 10^4$ to 1×10^6	--
Refrigerator/ Freezer	0.6- 1	1×10^3	--
Storage Cabinets		1×10^3	--
Misc.	1.6	$<1 \times 10^2$ to 1×10^4	--
TOTAL	24 - 64		

[a]Parenthetical values indicate the volume of a single piece of contaminated equipment.

Table 6.3

Projected Volumes of Radioactive Waste Arising from Decommissioning by NRC Regions through the Year 2000

NRC Region	Waste Volumes (m^3)		
	Category RD-2	Category RD-3	Total Volumes
1	1400-3600 140-1300[a]	310-830	2300-5700
2	100-260 10-100[a]	0	150-260
3	750-1800 70-670[a]	240-640	1300-3100
4	210-520 20-100[a]	0	260-620
5	160-390 20-140[a]	50-130	290-660
Total	2900-8900	600-1600	3500-10,500

[a]Wastes from decontaminated facilities where no components are disposed (i.e. cleaning and decontamination agents, etc.)

added to the total. All major components at all category RD-3 facilities have been assumed to require disposal with the contention that parts of certain components (e.g. lead bricks) can be reused without significantly reducing waste volumes. All facilities were assumed to have approximately the same types and amount of equipment, as specified in Tables 6.1 and 6.2. Miscellaneous wastes (e.g. cleaners, etc.) from RD-1 facilities are estimated to be 90 m^3, and have been added to the U.S. total but not the regional totals in Table 6.3. The total estimate of the radioactive waste from R&D facilities in the United States is 3500-10,500 m^3. The greatest impact will be in the northeast (NRC Region 1). It is estimated that 2300-5700 m^3 of radiological waste will be generated in this region due to decommissioning by 2000. The three regions with commercial burial facilities will generate the least amount of waste.

6.2 Conclusions

Basically, all independent R&D facilities in the U.S. can be divided into three classes according to the nature of operations, quantities and forms of radioactive materials authorized for posssession, and special problems at each which may influence decommissioning. The categories have been identified as RD-1, RD-2, and RD-3. The majority of facilities are in category RD-1 which is the least restrictive from a radiological standpoint. Only 3% of the facilities have been assigned to category RD-3 which is the most restrictive category.

As noted previously, individual facilities may deviate significantly from the estimates of potential radioactive waste in Tables 6.1 and 6.2. However, these values and the estimates presented in Table 6.3 are thought to be representative of the actual magnitude of the radioactive waste problem from decommissioning of independent research and development facilities. Waste generated at individual facilities can be projected using the volume estimates from Tables 6.1 and 6.2, and the actual list of equipment from the laboratory of concern.

This study did not consider accelerator facilities and the radioactive waste generated by D&D operations at those sites. These facilities are discussed in a separate report. (ERC82)

The fundamental conclusion from this analysis is that the volume of radioactive waste generated by the decontamination and decommissioning of independent research and development institutions is relatively small (approximately 3500-10,500 m^3 through the year 2000). This amount of waste is particularly small in comparison to the large volumes of radioactive waste that will be generated during decontamination and decommissioning of reactors, accelerators, and many other types of facilities. The radiological impact, even at RD-3 facilities, will still be low.

Special consideration should be given to facilities with on-site disposal or otherwise contaminated landscape. This problem can significantly increase the waste volumes for each facility from a few cubic meters to perhaps 1000 cubic meters.

Due to the nature of these R&D institutions, it is concluded that little radioactive waste will be generated in their decommissioning. This is true despite the uncertainties identified in documenting all R&D facilities and operations conducted at each. Even if the volume were several times what has been estimated, there should be no significant impact on disposal operations.

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DOT80 Department of Transportation, 1980, "Transportation," Code of Federal Regulations, Title 49.

ERC82 Evaluation Research Corporation, (in press), "Characterization of Contaminated Nuclear Sites, Facilities and Materials (Accelerators)," prepared for the U.S. Environmental Protection Agency.

Fa80 Faust, R.A., C.S. Fore, N.P. Knox, September 1980, "Nuclear Facility Decommissioning and Site Remedial Actions, A Selected Bibliography, Volume 1," Oak Ridge National Laboratory, Oak Ridge, TN, ORNL/EIS-154/VI, RHO/SFM-80/5.

ICRP64 International Commission on Radiological Protection. 1964. Report of Committee V on the Handling and Disposal of Radioactive materials in Hospitals and Medical Research Establishments, Publication 5 (New York, Pergamon Press).

ICRP77 International Commission on Radiological Protection, 1977, Recommendations of the ICRP, Publication 26, (New York, Pergamon Press).

Ko81 Kocher, D.C., 1981, "Radioactive Decay Data Tables: A Handbook of Decay Data for Application to Radiation Dosimetry and Radiological Assessments," DOE/TIC-11026.

Le78 Leggett, R.W., H.W. Dickson, and F.F. Haywood, 1978, "A Statistical Methodology for Radiological Surveying," proceedings of the Symposium on Advances in Radiation Protection Monitoring, June 26-28, 1978, Stockholm, Sweden.

Mu81 Murphy, E.S., February 1981, "Technology, Safety and Costs of Decommissioning Reference Non-Fuel-Cycle Nuclear Facilities," Prepared by Pacific Northwest Laboratory, Richland, WA for the U.S. Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-1754.

NCRP71 National Council on Radiation Protection and Measurements, January 1971, "Basic Radiation Protection Criteria," NCRP Report No. 39.

Nu79a Nuclear Regulatory Commission. 1979. "Licensing of Special Nuclear Material," Code of Federal Regulations, Title 10, Part 70.

Nu79b Nuclear Regulatory Commission. 1979. "Licensing of Source Material," Code of Federal Regulations, Title 10, Part 40.

Nu79c Nuclear Regulatory Commission. 1979. "Licensing of By-product Material," Code of Federal Regulations, Title 10, Part 30.

Nu79d Nuclear Regulatory Commission. 1979. "Standards for Protection Against Radiation," Code of Federal Regulations, Title 10, Part 20.

Nu80 United States Nuclear Regulatory Commission, June 1980, "Guidelines for Decontamination of Facilities and Equpment Prior to Release for Unrestsricted Use of Termination of Licenses for Byproduct, Source or Special Nuclear Material," USNRC, Division of Fuel Cycle and Material Safety, Washington, D.C.

Nu81 United States Nuclear Regulatory Commission, January 1981, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," NUREG-0586.

Op79 Opelka, J.H., R.L. Mundis, G.J. Marmer, J.M. Peterson, B. Siskind, M.J. Kikta, December 1979, "Particle-Accelerator Decommissioning," Argonne National Laboratory, Argonne, IL, ANL/ES-82.

Pe76 Pernet, Ann, 1976, Nuclear Research Index, (British Isles: Francis Hodgson Books, Ltd.).

APPENDIX A.

LIST OF R&D FACILITIES BY CATEGORY

Category RD-3 Facilities	Reference
Abbott Laboratories 1400 Sheridan Rd. North Chicago, IL 60064	8
*Aerojet-General Corp. San Ramon, CA	8,2,3
*Allied Chemical Corp. Corporate R&D Division P.O. Box 1021R Morristown, NJ 07960	8
*American Cyanimid Co. Pearl River, NY	22
Bell Telephone Laboratories, Inc. Murray Hill, NJ 07971	8
*Curtiss-Wright Corp. Quehanna, PA	8,23
*Dow Chemical Co. Midland, MI	8,23
*Industrial Nucleonics Corp. 1205 Chesapeake Avenue Columbus, OH	22
*Isotopes Specialties Co., Inc. Burbank, CA	8
Mallinckrodt Inc. 675 Brown Road Hazelwood, MO 63043	8
Martin-Marietta Corp. (Martin Co.) Martin Co. Baltimore, MD	8,23
*Middle River, MD	8,23
Minnesota Mining and Manufacturing Maintenance Department 3M Center St. Paul, MN 55101	8
*Monsanto Research Corp. 1515 Nicholas Rd. P. O. Box 8 Dayton, OH 45407	8,7
New England Nuclear Corp. 575 Albany St. Boston, MA	8

*Terminated

Category RD-3 Facilities	Reference
Billerica, MA	22
*15 Harvard Street Worcester, MA 01608	8
*Nuclear Consultants Inc. St. Louis, MO	8,22
*Nuclear Science and Engineering Corp. Homestead, PA	8
*Pfizer Inc. Brooklyn, NY	8
*Taylor Forge and Pipe Works 4735 W. 14th Street Cicero, IL	23
*United States Radium Corp. RD #5 Bloomsburg, PA	8,22
Upjohn Co. 7000 Portage Rd. Kalamazoo, MI 49001	8
Laboratory Procedures East 1075 First Ave. King of Prussia, PA 19406	8

*Terminated

Category RD-2 Facilities	Reference
A.J. Testing Laboratories, Inc. 580 Myrtle Avenue Brooklyn, NY 11205	2
*ACF Industries, Incorporated 508 Kennedy St., N.W. Washington, DC (facility in Maryland)	22
Adirondak Steel Casting Co., Inc. Metalurgical Laboratory Watervliet, NY 12189	2
Aerospace Corp. 2350 E. El Segundo Blvd. El Segundo, CA 90245	8
*Alco Products, Inc. 1 Nott Street Schenectady, NY	24
Allied Chemical Corp. General Chemical Division Morristown, NJ	8
*Specialty Chemicals Division 20 Peabody Street Buffalo, NY 14210	2
American Cyanamid Co. 1937 W. Main St. Stamford, CT 06904	8
*Lederle Laboratories Pearl River, NY 10965	2
American Home Products Corp. Ayerst Laboratories, Inc. Analytical Development Lab. 64 Maple Street Rouses Point, NY 12979	2,9
*American Hospital Supply Corp. Harleco Division 60th & Woodland Ave. Philadelphia, PA 19143	8
American-Pharmaceutical Co. 245 Fourth St. Passiac, NJ 07055	9

*Terminated

Category RD-2 Facilities	Reference
Americas Inc. Pharmaceuticals Group New Murphy Rd. and Concord Pi. Wilmington, DE 19899	8
AMR Biological Research Inc. PO Box 5700 Princeton, NJ 08540	8
Anoroc Industries, Inc. 93 Cedarlawn Blvd. Valley Stream, NY 11580	9
*Ansul Chemical Co. 1 Stanton St. Marinette, WI 54143	8
*Anton Electronic Laboratories, Inc. 1226-38 Flushing Avenue Brooklyn, NY	22
Applied Science Laboratories, Inc. 135 N. Gill St. P. O. Box 440 State College, PA 16801	9
The ARO Corporation Buffalo Division 3695 Broadway Buffalo, NY 14225	2
Astra Pharmaceutical Products, Inc. Ashland Petroleum Company 4545 River Road Tenawanda, NY 14150	2
*Atlantic Testing Laboratory Potsdam-Canton Road Canton, NY 13617	2
AVCO Everett Research Laboratory, Inc. Everett, MA 02149	9
*AVCO/Electronics Division 201 Lowell St. Wilmington, MA 01887	8,22
*W.F. and John Barnes Co. Applied Physics Department 1920 11th Street Rockford, IL	22

*Terminated

Category RD-2 Facilities	Reference
*Bartol Research Foundation Whittier Place Swarthmore, PA 19081	8
Becton, Dickinson & Co. Schwarz-Mann Division Mountain View Ave. Orangeburg, NY 10962	9
Bell Aerospace Textron Division of Textron, Inc. P.O. Box 1 Niagara Falls Boulevard Buffalo, NY 14240	2
*Bendix Corp (The) 203 W. 3rd Street Cincinnati, OH	8
Bendix Center Southfield, MI 48076	8
*Navigation and Control Div. Teterboro, NJ 07608	8
Electrical Components Division Delaware Avenue Sidney, NY 13838	2
*Fluid Power Division 211 Seward Avenue Utica, NY 13503	2
*Bio-Research Institute Inc. 9 Commercial Ave. Cambridge, MA 02141	8
Bio-Resources Inc. 212 N. Bassett St. Madison, WI 53703	8
Bio-Science Laboratory 19701 S. Miles Rd. Warrensville, OH 44128	8
*Bio-Technical Resources Inc. 7th and Marshall Sts. Manitowoc, WI 54220	8
Biogenics Research Corp. 12728 Aquilla Rd. Chardon, OH 44024	8

*Terminated

Category RD-2 Facilities	Reference
Biolabs Inc. 2910 MacArthur Blvd. Northbrook, IL 60062	8
Bjorksten Research Laboratories, Inc. P.O. Box 9444 Madison, WI	8
*Boing Airplane Co. Seattle, WA	22
Boeing Scientific Research Center 1420 S. Trenton Street Seattle, WA 98124	5
Booz Allen & Hamilton Inc. Foster D. Snell Division 66 Hanover Road Florham Park, NJ 07932	8
*Borg-Warner Corp. Roy C. Ingersoll Research Center Wolf and Algonquin Road Des Plaines, IL 60018	8
Bristol-Myers Company Bristol-Myers Products Div. 225 Long Ave. Hillside, NJ 07207	8
Brooks-Willamette Corp. 1 S. Hill Street Bend, Oregon 97701	10
*Budd Co. Nuclear Systems Division Philadelphia, PA	8,22
Calspan Corporation P.O. Box 235 4455 Genesee Street Buffalo, NY 14221	2
Cambridge Nuclear Corp. Radiopharmaceutical Div. 575 Middlesex Tpk. Billerica, MA 01821	8
Cancer Research Center 115 Business Loop 70 West Columbus, MO 65201	3

*Terminated

Category RD-2 Facilities	Reference
*The Carborundum Company Globar Plant 3425 Hyde Park Blvd. Niagara Falls, NY 14302	2
*Research and Development Division Niagara Falls, NY 14302	2
CBT Laboratories Inc. 1436 Old Skokie Rd. Highland Park, IL 60035	8
Center for Blood Research 800 Huntington Ave. Boston, MA 02115	8
Central Electric Time Corp. 1179 Tower Rd. Schaumburg, IL 60195	8
Chrysler Corp. 12800 Oakland Highland Park, MI 48231	8
*CIBA Corp. CIBA Pharmaceutical Co. Div. 556 Morris Ave. Summit, NJ 07901	8
CIBA-GEIGY Corporation 180 Mill Street Cranston, RI 02905	1
*410 Swing Road P.O. Box 11422 Greensboro, NC 27409	2
Pharmaceutical Division Saw Mill River Road Ardsley, NY 10502	2
Citation Clinical Laboratories 23685 Northwestern Highway Southfield, MI 48075	8
Clin-Chem Laboratories Inc. 1106 Commonwealth Ave. Boston, MA 02215	8
Clinton Valley Specialty Lab. Inc. 3722 Elizabeth Lake Road Pontiac, MI 48054	8

*Terminated

Category RD-2 Facilities	Reference
Colt Industries, Crucible, Inc. Specialty Metals Division P.O. Box 977 Syracuse, NY 13201	2
*Commercial Solvents Corp. 1331 S. 1st St. Terre Haute, IN 47808	8
*Convair - A Div. of General Dynamics Corp.	8
Fort Worth, TX	
Corning Glass Works Corning Medical 333 Coney SSt. Walpole, MA 02032	8
*Curtiss-Wright Corp. 60 Grider St. Buffalo, NY	8
Clifton, NJ	8
Carlstadt, NJ	8
*Dow Chemical Co. Freeport, TX	8,23
Human Health Research Laboratories P.O. Box 68511 Indianapolis, IN 46268	8
Granville Research & Development Center P. O. Box 515 Granville, OH 43023	8,22
New England Laboratory Box 400 Wayland, MA 01778	8
Dunlop Tire and Rubber Corporation P.O. Box 1109 Buffalo, NY 14240	2
Dynatech R/D Co. Chemical Engineering Dept. 99 Erie St. Cambridge, MA 02175	8
*E.I. DuPont de Nemours & Co., Inc. Wilminton, DE	22

*Terminated

Category RD-2 Facilities	Reference
*E.I. DuPont de Nemours & Co., Inc. Industrial Chemicals Dept. Buffalo Avenue Niagara Falls, NY 14302	2
*E.I. DuPont de Nemours & Co., Inc. Pennsgrove, NJ	8
*Eastman Kodak Co. Distillation Products Industries 755 Ridge Road West Rochester,NY 14650	2
Paper Sensitizing Division 1669 Lake Avenue Rochester, NY 14650	2
EG&G Bionomics Inc. Main St. Wareham, MA 02571	8
Electronic Products Co. 111 East 3rd St. Mount Vernon, NY	22
Eli Lilly and Co. Kentucky Avenue Indianapolis, IN 46206	8,12
Emergency Care Research Institute 5200 Butler Pike Plymouth Meeting, PA 19462	8
Exxon Company, USA Exxon Production Research Co. P.O. Box 2189 Houston, TX 77001	8,9
Falzone Medical Laboratory Inc. Radioimmunoassay Dept. 3535 Fort St. Lincoln Park, MI 48146	8
*Farnsworth Electronics Co. Research Department 3702 E. Pontiac St. Fort Wayne, IN	22
Foundation for Blood Research P.O. Box 426 Scarborough, ME 04074	8

*Terminated

Category RD-2 Facilities	Reference
GAM TEK Diagnostics, Inc. 23840 Van Born Road Dearborn Heights, MI 48125	8
*Gamma Corp. Budd Co. Philadelphia, PA	8
Gamma Industries, Inc. A Division of Nuclear Systems, Inc. P. O. 2543 Baton Rouge, LA 70821	4
*General Airline & Film Corp. 457 Lincoln St. Easton, PA 18042	8
*General Dynamics Corp. San Diego, CA	8
*Ft. Worth, TX	8
*Electric Boat Division Eastern Point Rd. Groton, CT 06340	22
General Motors Corp. 30800 Mound Road Warren, MI 48090	8
*Milwaukee, WI 53201	8
*General Nuclear Inc. 9320 Tavenor Houston, TX 77034	8
*General Time Corp. Westclox Div. La Salle, IL 61301	8
General Tire & Rubber Co. (The) One General St. Akron, OH 44329	8
Goodyear Tire & Rubber Co. (The) 142 Goodyear Blvd. Akron, OH 44316	8,13
Gulf Research & Development Co. P.O. Drawer 2038 Pittsburgh, PA 15230	8

*Terminated

Category RD-2 Facilities	Reference
*Hamilton Watch Company Dial Finishing Department 901 Columbia Avenue Lancaster, PA 17604	8
*Harte and Co., Inc. 49 Dupont St. Brooklyn, NY 11222	2
*Herbert Products, Inc. 180 Linden Avenue Westbury, NY 11590	2
*Hooker Chemicals & Plastics Corp. Walck Rd. North Tonawanda, NY 14120	2
Horizons Research Incorporated 23800 Mercantile Road Cleveland, OH 44122	8
*Princeton, NJ	23
Humble Oil & Refinery Co. Houston, TX	22
Hydro Med Sciences Inc. 783 Jersey Avenue New Brunswick, NJ 08902	8
*ICN-K & K Laboratories, Inc. 121 Express St. Plainview, NY 11803	2
ICN Pharmaceuticals, Inc. ICN-Chemicals and Radioisotopes Div. 2727 Campus Dr. Irvine, CA 92715	9
IMC Chemical Group Inc. Research Department 1221 South Firest Street Terre Haute, IN 47808	8
Immuno Nuclear Corporation 6303 Osgood Avenue North Stillwater, MN 55082	8
*Inc. Air Products and Chemicals P. O. Box 538 Allentown, PA 18105	8

*Terminated

Category RD-2 Facilities	Reference
*Inc. Microbac Laboratories 4580 McKnight Road Pittsburgh, PA 15237	8
Industrial Bio-Test Laboratories Inc. Metabolism and Radiotracer Department 1810 Frontage Road Northbrook, IL 60062	8
*Industrial Nucleonics Corp. 312 Florida Avenue West Palm Beach, FL	22
Inolex Corporation Pharmaceutical Division 2600 Bond Street Park Forrest South, IL 60466	8
The Institute of Paper Chemistry Organic Chemistry Section 1043 East South River Street Appleton, WI 54911	8
International Foundation for Cancer Research Dept. of Biochemistry 6626 Westline Drive Houston, TX 77036	3
*The International Nickel Co., Inc. Sterling Forest Suffern, NY 10901	2
International Research & Development 500 North Main Street Mattawan, MI 49071	8
IRT Corp. 7650 Convoy Court San Diego, CA 92138	9
*Isolab Inc. Drawer 4350 Akron, OH 44321	8
*Isotopes, Inc. Westwood, NJ	8
*Isotope Products, Inc. Buffalo, NY	8
Jackson Laboratory (The) Radioisotope Laboratory Otter Creek Rd. Bar Harbor, ME 04609	3

*Terminated

Category RD-2 Facilities	Reference
*Johns-Manville Research Center Manville, NJ	8
Johnston Laboratories, Inc. 3 Industry Lane Cockysville, MD 21030	4
K-V Pharmacal Company 2503 South Hanley Road St. Louis, MO 63144	8
Kaman Sciences Corporation Nuclear Controls and Electronics Division 195 West 2950 South Salt Lake City, UT 84115	8
*Keystone Chemurgic Corp. Bethlehem, PA	8
*Koch Isotopes Inc. 72 Rogers Street Cambridge, MA 02142	8
Liquid Carbonic Corporation 3740 West 74th Street Chicago, IL 60629	8
*Litton Bionetics Inc. Drug Metabolism Section 101 West Jefferson Street Falls Church, VA 22046	8
P.O. Box B Frederick, MD 21701	8
*LND Inc. 3230 Lawson Boulevard Oceanside, NY 11572	2
Lockheed Aircraft Corporation Lockheed Missiles & Space Company 1111 Lockheed Way Sunnyvale, CA 94088	8,23
Palo Alto, CA	8
Burbank, CA	8
Lockheed-Georgia Company 86 South Cobb Drive Marietta, GA 30060	8

*Terminated

Category RD-2 Facilities	Reference
*Luminous Processes Inc. 801 Clinton Street Ottawa, IL 61350	8
Mallinckrodt Inc. 3600 North Second Street St. Louis, MO 63160	8
Manlabs, Inc. 21 Erie St. Cambridge, MA 02139	9
*Marquardt Corp. Marquardt Aircraft Co. Monrovia, CA	23
*Martin Co. Denver, CO	23
MCB Manufacturing Chemists Inc. 2909 Highland Avenue Cincinnati, OH 45212	8
*McDonnel Douglas Corporation Douglas Missile and Space Systems Division 3000 Ocean Park Boulevard Santa Monica, CA 90406	8
St. Louis, MO 63166	8
Mead-Johnson Granville, IN	17
Merrell-National Laboratories Richardson-Merrell Inc. 1707 East North Avenue Milwaukee, WI 53202	8
MG Scientific Gases 210 Cougar Ct. Somerville, NJ 08876	8
Midland Macromolecular Institute Biomedical Research Unit 1910 West Street, Andrews Drive Midland, MI 48640	8
*Minnesota Mining and Manufacturing Photo Products Division 1999 Mount Read Blvd. Rochester, NY 14615	2
*Honeoye, NY 14471	2

*Terminated

Category RD-2 Facilities	Reference
*American Lava Corp. Chattanooga, TN	23
Monsanto Company Research Center Corporate Research & Development, Bio-Med 800 N. Lindbergh Boulevard St. Louis, MO 63166	8
*Monsanto Research Corp. Texas City, TX	22
*Morton-Norwich Products, Inc. Norwich-Eaton Pharmaceuticals, Inc. Woods Corners Norwich, NY 13815	2
National Fishery Research Lab. P. O. Box 818 La Crosse, WI	3
*New York Testing Laboratories, Inc. 81 Urban Ave. Westbury, NY 11590	2
NL Industries, Inc. Nuclear Metals Division 1130 Central Avenue Albany, NY 12205	2
*Nord Photo Engineering Inc. 529 S. Seventh St. Minneapolis, MN 55415	8
*Norton Co. 1 New Bond Street Worcester, MA	23
Nuclear Equipment Chemical Corp. 165 Marine St. Farmingdale, NY 11735	2
Nuclear Metals Inc. 2229 Main St. Concord, MA 01742	7
*Nuclear Radiation Developments Corp. 2937 Alt Blvd. Grand Island, NY	2
Nuclear Sources and Services Inc. 5711 Ethridge Houston, TX	9

*Terminated

Category RD-2 Facilities	Reference
*Olin Chemicals Niagara Falls Plant 2400 Buffalo Avenue Niagara Falls, NY 14302	2
Orlando Laboratories Inc. 90 W. Jersey St. Orlando, FL 32806	9
*Orlando Research Inc. Orlando, FL	8
*Ortho Pharmaceutical Corp. US Highway 202 Raritan, NJ 08869	8
P-L Biochemicals Inc. 1037 W. McKinley Ave. Milwaukee, WI 53205	8
Parke Davis and Co. Warner-Lambert Pharmaceutical Research Div. 2800 Plymouth Rd. Ann Arbor, MI	8
Warner-Lambert Research Inst. 170 Tabor Rd. Morris Plains, NJ 07950	8
Joseph Campau at the River Detroit, MI 48232	8
*Pennwalt Corp. Pharmaceutical Division 755 Jefferson Rd. Rochester, NY 14623	2
Pfizer Inc. 199 Maywood Ave. Maywood, NJ 07607	8
Terre Haute, IN 47801	8
Groton, CT	8
Pineapple Research Institute of Hawaii 2500 Dole Street Honolulu, HI	22
Polaroid Corp. 730 Main St. Cambridge, MA 02139	8

*Terminated

Category RD-2 Facilities	Reference
Procter & Gamble Co. (The) Ivorydale Technical Center Cincinnati, OH 45217	8,22
*P. O. Box - A 366 Richmond Terraace Staten Island, NY 10314	2
*Radiac Research Corp. 261 Kent Ave. Brooklyn, NY 11211	2
*Radio Corp. of America Tube Division 3301 S. Adams Street Marion, OH	24
*Radiotracer Group Chemical and Physical Laboratory New Holland Pike Lancaster, PA 17604	8
*Radiological Research Inst., Inc. Denver, CO	8
*Radionics Inc. Norristown, PA	8,24
*Radium Chemical Co., Inc. New York, NY	8,2
*RAI Research Corp. 225 Marcus Blvd Hauppauge, NY 11787	2
Raytheon Co. P. O. Box 300 Portsmouth, RI 02871	1
*Reynolds Metals Co. Plastics Research and Development P.O. Box 128 Grottoes, VA 24441	8
RI Analytical Labs, Inc. 231 Elm Street Warwick, RI 02888	1
*Reynolds Metals Co. Plastics Research and Development P.O. Box 128 Grottoes, VA 24441	8

*Terminated

Category RD-2 Facilities	Reference
RI Analytical Labs, Inc. 231 Elm Street Warwick, RI 02888	1
Richardson-Merrell Inc. Jensen-Salsbery Laboratiries Div. Research Dept. 520 W. 21st ST. Kansas City, MO 64141	8
*Merrell-National Laboratories Div. Biological Laboratories Swiftwater, PA 18370	8
*Ross Laboratories Research Dept. 625 Cleveland Ave. Columbus, OH 43216	8
Safety Light Corporation 4150-A Old Berwick Rd. Bloomsburg, PA 17815	7
*Saxton Nuclear Experimental Corp. P.O. Box 99 Saxton, PA 16678	8
Science Applications, Inc. Advanced Nucleonics Laboratory 1257 Tasman Dr. Sunnyvale, CA 94086	9
*Scinti-Log Inc. P.O. Box 434 Casper, WY 82601	8
SC Johnson & Son Inc. 1525 Howe St. Racine, WI 54303	8
SCM Corp. Glidden-Durkee Div. 2900 Middle Road Ashtabula, OH 44004	8
Sealed Power Corp. 100 Terrace Plaza Muskegon, MI 49443	8
*Searle Diagnostic, Inc. 1210 Jefferson Rd. Henrietta, NY 14623	2

*Terminated

Category RD-2 Facilities	Reference
*Shell Oil Co. Houston, TX	22
Sherex Chemical Co. Inc. P.O. Box 646 Diblin, OH 43017	8
Sherwin-Williams Co. (The) 11541 Champlain Ave. Chicago, IL 60628	8
*Sigma Laboratories, Inc. 88-11 31st Avenue East Elmhurst, NY 11369	2
SISA Inc. Dept. of Pharmacology 767B Concord Ave. Cambridge, MA 02138	8
Smith Kline and French Laboratories 1500 Spring Garden St. Phildelphia, PA 19101	8
Leary Laboratory Division 343 Winter St. Waltham, MA 02154	8
*Solid State Products Co. Solid State Products Co. Div. One Pingree St. Salem, MA 01970	8
Source Production and Equipment Co. 625 Oxley St. Kenner, LA 70062	4
*Southern Research Institute Birmingham, AL	23
Southwest Foundation for Research and Education 7480 W. Commerce St. Box 28147 San Antonio, TX 78284	3,22
Southwest Research Inst. San Antonio, TX	8
Spire Corp. Nuclear Science Dept. Patriots Park Bedford, MA 01730	8

*Terminated

Category RD-2 Facilities	Reference
Squibb Institute for Medical Research New Brunswick, NJ	
Standard Oil Co. (OH) Research Department 4440 Warrensville Center Rd. Cleveland, OH 44128 (other sites also)	8
Stauffer Chemical Co. Eastern Research Center Dobbs Ferry, NY 10522	2
*Sterling Drug, Inc. Sterling Organics U.S. 33 Riverside Ave. Rensselaer, NY 12144	2
Sterling-Winthrop Research Institute Div. of Sterling Drug, Inc. Rensselaer, NY 12144	2
Teledyne Isotopes Westwood, NJ 07675	9
Texaco, Inc. Beacon Research Laboratories P.O. Box 509 Beacon, NY 12503	2
*Texas Nuclear Corp. Austin Nuclear Corp. Austin, TX	8,22
Thermo Electron Corp. Cancer Research Div. 45 First Ave. Waltham, MA 02154	8
Eberline Instrument Corp. Airport Rd. Santa Fe, NM 87501	9
Timex Clock Co. P.O. Box 1700 Waterbury, CT 06721	8
Toxigenics, Inc. 1800 E. Pershing Rd. Decatur, IL 62526	8
*U.S. Steel Corp. 600 Grant St. Pittsburgh, PA 15230	8

*Terminated

Category RD-2 Facilities	Reference
U S V Pharmaceutical Corp. Pharmacology Dept. 1 Scarsdale Rd. Tuckahoe, NY 10707	2
*Ultrachem Biomedical lab. 5700 Far Hills Ave. Dayton, OH 45429	8
Union Carbide Research and Development Dept. Brookside Ave. Ambler, PA 19002	8
12900 Snow Rd. Parma, OH 44130	8,22
*Research and Development Dept. 4625 Royal Avenue Niagara Falls, NY 14302	2
*Process and Product Development 61 E. Park Dr. Tonawanda, NY 14150	2
*Sterling Forest Research Center P.O. Box 324 Tuxedo, NY 10987	2
Uniroyal Inc. Uniroyal Chemical Div. Chemical Research Group Elm Street Naugatuck, CT 06771	8
Uniroyal Tire Co. 6600 E. Jefferson Ave. Detroit, MI 48232	8
United Color Corp. Rd. 1, Box 332 C Ashland, OH 48005	8
*Rte. 3, Sawmill Ridge Rd. Newtown, CT 06470	8
United States Testing Co. Inc. 1415 Park Ave. Hoboken, NJ 07030	8
Velsicol Chemical Corp. 341 E Ohio St. Chicago, IL 60611	8

*Terminated

Category RD-2 Facilities	Reference
Warren-Teed Pharmaceuticals Inc. Division of Rohm and Haas Co. 582 W. Goodale St. Columbus, OH 43215	8
*Welex Jet Services, Inc. 1400 East Berry Street Fort Worth, TX	24
*Westinghouse Electric Corp. Research Dept. Macarthur Ave. Bloomfield, NJ 07003	8
Westwood Research Laboratory Inc. 543 High St. Westwood, MA 02090	8
Woodard Research Corp. 12310 Pinecrest Rd. Herndon, VA 22070	8
Wyeth Laboratories Inc. P.O. Box 8299 Phildelphia, PA 19101	8
*Radnor, PA	8
Wyle Laboratories 3200 Magruder Blvd. Hampton, VA 23666	8
Youngstown Sheet & Tube Co. P.O. Box 900 Youngstown, OH 44501	8

*Terminated

Category RD-1 Facilities	Reference
Abcor Inc. 850 S. Main St. Wilmington, MA 01887	8
ACF-FILCO Corporation 3333 W. Warner Ave. Santa Ana, CA 92704	9
Advanced Mechanical Technology Inc. Engineering Dept. 141 California St. Newton, MA 02158	8
Advanced Technology Labs., Inc. 425 Merrick Avenue Westbury NY 11746	9
*Aerojet-General Corp. Azuza, CA	3,22
Agway, Inc. Agway Technical Center Ithaca, NY 14850	2
Airco, Inc. Central Research Laboratories 100 Mountain Ave. Murray Hill, NJ 07974	8
Airco Speer Carbon-Graphite Packard Rd. at 47th Street Niagara Falls, NY 14302	2
*Albany International Corp. Albany Felt Company Chemical Research & Development Dept. 1373 Broadway Albany, NY 12201	2
Alberto Culver Co. 2525 Armitage Melrose park, IL 60160	8
Alderson Research Laboratories, Inc. 390 Ludlow St. P. O. 1271 Stanford, CT 06904	9
Allen-Bradley Co. Physics and Materials Lab-814 1201 S 2nd St. Milwaukee, WI 53204	8

*Terminated

Category RD-1 Facilities	Reference
Allied Engineering & Prod. Corp. 2421 Blanding Avenue Alameda, CA 94501	9
*Allis-Chalmers Engine Division Box 563 Harvey, IL 60426	8
*Alpha Portland Industries, Inc. Alpha Portland Cement Company P.O. Box 138 Cementon, NY 12415	2
*P.O. Box 388 Rock Cut Road Jamesville, NY 13078	2
Aluminum Co. of America Alcoa Technical Center P.O. Box 2970 Alcoa Center, PA 15069	8
American Hoechst Corp. 129 Quiduick St. Coventry, RI 02816	1
*American Machine and Foundry Co. 5502 Second Avenue Brooklyn, NY	22
*American Potash and Chemical Corp. W. Chicago, IL	8
American Science & Engineering Inc. 955 Massachusetts Ave. Cambridge, MA 02139	8
*American Tradair Corp. Long Island City, NY	8
AMP Inc. Harrisburg, PA 17105	8
Amperex Electronic Corporation 230 Duffy Avenue Hicksville, NY 11802	2
*Amstar Corporation 49 South Second Street Brooklyn, NY 11211	2

*Terminated

Category RD-1 Facilities	Reference
Amtrol Inc. 1400 Division Road West Warwick, RI 02893	1
The Anaconda Co. 1849 W. North Temple Salt Lake City, UT 84116	8
*Anheuser-Busch Inc. 721 Pestalozzi St. St. Louis, MO 54143	6
Anyl-Ray Corp. 73 Pond St. Waltham, MA 02154	8
*Apache Alarm Co., Inc. 26 Oxford St. Lynn, MA 01901	8
Applied Physical Technology, Inc. 2734 S. Cobb Ind. Blvd. Smyrna, GA 30080	18
Applied Research Laboratories of Florida, Inc. P. O. Box 489 Hialeah, FL 33011	9
Archer Daniels Midland Co. 4666 Faries Parkway Decatur, IL 62526	8
ARCO Petroleum Products Co. 3144 Passyunk Ave. Philadelphia, PA 19101	1
*Armour-Dial Inc. Research and Development Dept. 3115 S. Benson St. Chicago, IL 60608	8
Armstrong Cork Co. Research and Development Center 2500 Columbia Ave. Lancaster, PA 17604	8
Arnar-Stone Laboratories Inc. Research and Administrative Center 1600 Waukegan Road McGaw Park, IL 60085	8

*Terminated

Category RD-1 Facilities	Reference
*ARTCO Research & Development Laboratories, Inc. Runyon Testing Laboratories 434 S. Wabash Avenue Chicago, IL 60605	8
Ashland Oil Inc. R&D Division P.O. Box 2219 Columbus, OH 43216	8
Astra Research Laboratory PO Box 1089 Framingham, MA 01701	8
Atlantic Richfield Co. 400 E. Sibley Blvd. Harvey, IL 60426	8
260 S. Broad Street Philadelphia, PA 19101	7
*AVCO/Electronics Division 2630 Glendale Milford Rd. Cincinnati, OH 45241	8
*550 Main St. Stratford, CT 06497	8
*10700 E. Independence St. Tulsa, OK 74115	8
Baird Corporation Nuclear Division 125 Middlesex Turnpike Bedford, MA 01730	9
Barnebey-Cheney Co. 835 N. Cassady Ave. Columbus, OH 43219	8
BASF Corp. 100 Cherry Hill Rd. Parsippany, NJ 07054	8
Wyandotte, MI 43192	8
Bedford Engineering Corp. 124 South Road Bedford, MA 01730	8
Bendix Corp. (The) Aerospace Systems Div. 1919 Green Road Ann Arbor, MI 48107	22

*Terminated

Category RD-1 Facilities	Reference
*Bendix Corp. (The) Friction Materials Division P.O. Box 238 Troy, NY 12181	2
*Benrus Corporation 250 Hudson Street New York, NY 10036	2
*Beospherics Research Inc. 4928 Wyaconda Road Rockville, MD 20853	8
Bethlehem Steel Corp. Room B-252 Martin Tower Bethlehem, PA 18016	8
Lackawanna Plant So. 3556 Lake Shore Road Buffalo, NY 14219	2
Bigelow Laboratory for Ocean Science Box 117-McKown Point W. Boothbay Harbor, ME 04575	3
Bio-Dynamics/BMC 9115 Hague Road Indianapolis, IN 46250	8
*Bio-Tec Inc. 908 E. 56th ST. Minneapolis, MN 55417	8
*Biocentrix Star Route Canby Road Levering, MI 49755	8
Biomarine Industries Inc. 303 W. Lancaster Ave. Devon, PA 19333	8
45 Great Valley Center Malvern, PA 19355	8
*Biometric Testing Inc. 661 Palisade Avenue Englewood Cliffs, NJ 07632	8
*Biosearch, Inc. P.O. Box 8598 Philadelphia, PA 19101	8

*Terminated

Category RD-1 Facilities	Reference
*Bituminous Coal Research Inc. 350 Hochberg Rd. Monroeville, PA 15146	8
*Bomac Laboratories Inc. Beverly, MA	8
*Borden, Inc. Research Centre 600 North Franklin Street Syracuse, NY 13204	2
*Boulder Scientific Co. Research Dept. 250 Pearl St. Boulder, CO 80301	8
Bristol Metal Co. 58 Broad Common Road Bristol, RI 02809	1
Bristol-Myers Company Thompson Road East Syracuse, NY 13057	2
*Brookes & Gatehouse, Inc. 154 East Boston Post Road Manaroneck, NY 10543	2
Buckbee-Mears Company P.O. Box 189 Kellogg Road Cortland, NY 13045	2
*Burgess Vibrocrafters Inc. Route 83 Grayslake, IL 60030	8
Callanan Industries, Inc. South Bethlehem, NY 12161	2
Campbell Soup Co. Campbell Place Camden, NJ 08101	8
Cannon Laboratories Inc. R.D. #2 P.O. Box 3627 Reading, PA 19605	8
*Carlex Corp. Unlimited 193 Hoffman Blvd. E. Orange, NJ 07017	8

*Terminated

Category RD-1 Facilities	Reference
Carrier Corporation Carrier Parkway Syracuse, NY 13201	2
Carter-Wallace Inc. Wallace Laboratories Div. Wampole Laboratories Div. Half Acre Road Cranbury, NJ 08512	8
Cast Iron Pipe Research Assn. 1301 W. 22nd St. Oak Brook, IL 60521	8
Caterpillar Tractor Co. Research Dept Technical Center, Bldg. E Peoria, IL 61602	8
*CBS-Hytron Research and Development Dept. 100 Endicutt Street Danvers, MA	22
Celanese Corp. Celanese Research Co. Summit Laboratory Morris Court Summit, NJ 07901	8
The Celotex Corporation Subsidiary of Jim Walker Corporation Laurel Bank Avenue Deposit, NY 13754	2
*Century Geophysical Corp. 6540 East Apache Tulsa, OK 74115	8
Charles F. Kettering Foundation 150 E South College St. Yellow Springs, OH 45387	8
Charles Stark Draper Laboratory Inc. 555 Technology Square Cambridge, MA 02139	8
Chevron Research Co. 576 Standard Ave. Richmond, CA 94802	8
Chloride Pyrotector Inc. 333 Lincoln St. Hingham, MA 02043	8

*Terminated

Category RD-1 Facilities	Reference
Cincinnati Electronics Corp. 2630 Glendale-Milford Rd. Cincinnati, OH 45241	8
*Cleveland-Cliffs Iron Co. (The) 504 Spruce St. Ishpeming, MI 49849	8
Colgate Palmolive Research Center Research Center 909 River Rd. Piscataway, NJ 08854	8
Connaught Laboratories Inc. Product Improvement and Development Swiftwater, PA 18370	8
Conoco Coal Development Co. Research Div. Library, PA 15129	8
Conrac Corp. Rixon/Firemark Inc. Div. 9100 W. Belmont Ave. Franklin Park, IL 60131	8
*1600 S. Mountain Ave. Duarte, CA 91010	8
Cramer Div. Mill Rock Rd. Old Saybrook, CT 06475	8
Consolidated Controls Corp. P.O. Box 726 Springfield, VA 26150	8
*Continental Can Co., Inc. 7622 S. Racine Ave. Chicago, IL 60620	8
*Continental Oil Co. Research and Development Dept. Ponca City, OK 74601	8
Cooper Laboratories Inc. 110 E. Hanover Ave. Cedar Knolls, NJ 07927	8
Core Laboratories Inc. Research Development and Technical Services Dept. 7501 Stemmons Freeway Dallas, TX 75207	8,11

*Terminated

Category RD-1 Facilities	Reference
Corning Glass Works 1193 Broad Street Central Falls, RI 02863	1
Sullivan Science Park Research and Development Dept. Painted Post, Town of Erwin, NY	2
Crescent-Cooper Division Industries, Inc. 200 Harrison Street Jamestown, NY 14701	2
Crystaloid Electronics Co. 4976 Hudson Drive Stow, OH 44224	8
*Cummins Engine Co., Inc. 1000 Fifth Avenue Columbus, IN 47201	8
*Dana Corp. 552 S. Washington St. Hagerstown, IN 47346	8
John W. Danforth Company 1940 Fillmore Avenue Buffalo, NY 14214	2
Dart Industries Inc. Environmental Research Div. 3725 N. Dunlap St. St. Paul, MN 55112	8
Dekalb Agresearch Inc. Agronomic Research Center Sycamore Rd. Dekalb, IL 60115	8
*Dektron Instruments Post Office Box R245 Lockport, IL 60441	8
Detector Electronics Corp. 7351 Washington Ave. South Minneapolis, MN 55435	8
Diamond Shamrock Corp. (Diamond Alkali) T.R. Evans Research Center P.O. Box 348 Painesville, OH 44077	8

*Terminated

Category RD-1 Facilities	Reference
*Diamond Shamrock Health Science Inc. Reference Laboratory Division 37288 Olentargy River Rd. Columbus, OH 43214	8
*Dinsmore Instrument Co. Box 345 Flint, MI 48501	8
*Douglas Aircraft Co., Inc. Santa Monica, CA	8
Dow Corning Corp. Midland, MI 48640	8
Dresser Industries Inc. Galion Manufacturing Div. 352 South St. Galion, OH 44833	8
E.I. DuPont de Nemours & Co., Inc. Yerkes Plant Plastic Products & Resins Dept. Station B-River Road Buffalo, NY 14207	2
*E.I. DuPont de Nemours & Co., Inc. Photo Products Department 666 Driving Park Avenue Rochester, NY 14603	2
*Montague, MI	8
Chambers Works Deepwater, NJ 08023	8
Eastern Laboratory Service Assn. 26 N. Ridge Ave. York, PA 17403	8
Eastman Kodak Co. Health and Safety Laboratory Buidling 320-Kodak Park Rochester, NY 14650	2
1999 Lake Ave. Rochester, NY 14650	2
Kodak Apparatus Division 121 Lincoln Avenue Rochester, NY 14650	2

*Terminated

Category RD-1 Facilities	Reference
*Physics Division of Research Laboratories 2000 Lake Avenue Rochester, NY 14650	2
EccTest Laboratories, Inc. 170 Central Avenue Unit 1 Farmingdale, NY 11735	2
Eco-Control Inc. 56 Rogers St. Cambridge, MA 02142	8
*Ecodyne Corp. Graver Water Div. 2720 U.S. Rt. 22 Union, NJ 07083	8
Edax International Inc. 103 Schelter Rd. Prairie View, IL 60069	8
EG&G Inc. 45 William St. Wellesley, MA 02181	9
160 Brookline Avenue Boston, MA	22
*EG&G Bionomics Inc. Crosby Drive Bedford,MA 01730	8
*EICO Electronic Instrument Co., Inc. 108 New South Road Hicksville, NY 11801	2
Electric Power Research Institute (EPRI) 3412 Hillview Ave. Palo Alto, CA 94304	9
*Electro-Optical Systems, Inc. Pasadena, CA	8
*Emhart Corp. P.O. Box 2730 Hartford, CT 06101	8
EMR Photoelectric 20 Wallace Road Princeton Junction, NJ 08550	8
Endo Laboratories, Inc. 1000 Stewart Avenue Garden City, NY 11530	2

*Terminated

Category RD-1 Facilities	Reference
Energy Resources Co. Inc. 185 Alewife Brook Pkwy. Cambridge, MA 02138	8
Entronic Corp. 4348 Riverline Dr. Earth City, MO 63045	8
Envirex Inc. 4710 W. Greenfield Ave. Milwaukee, WI 53214	8
Environmental Consultants Inc. 46-132 Kahuhipa St. Keneohe, HI 96744	8
Environmental Research Group, Inc. 7777 Exchange St. Valley View, OH 44125	9
Eon Corporation 175 Pearl Street Brooklyn, NY 11201	9
ERM Electronics Inc. 203 Middlesex Tpk. Burlington, MA 01803	8
*ESB Inc. Technology Center 19 W. College Ave. Yardley, PA 19067	8
Ethicon Inc. Route 22 Somerville, NJ 08876	8
Ethyl Corp. Research Labs. 1600 W. Eight Mile Rd. Ferndale, MI 48220	8
Eureka Engineering Co., Inc. 11720 Moffitt Lane Manassas, VA 22110	8
*Exxon Co., USA River Road Glenmont, NY	2
*5 Canal Road Pelham Manor, NY	2

*Terminated

Category RD-1 Facilities	Reference
*401 Hiawatha Boulevard Syracuse, NY	2
*Facet Enterprises, Inc. Motor/Components Division 18th & Oakwood Avenue Elmira Heights, NY	2
*The Fafnir Bearing Co. 37 Booth Street New Brittain, CT 06050	8
*Fairchild Industries, Inc. Fairchild Republic Co. Farmingdale, NY 11735	2
Farr Co. 500 S. Main St. Crystal Lake, IL 60014	8
Faylor-Middlecreek Inc. P.O. Box 135 Winfield, PA 17889	8
Fibers Inernational Corp. Guayama Plant P.O. Box 635 Guayama, PR 00654	8
*Fisher Scientific Co. 711 Forbes Ave. Pittsburgh, PA 15219	8
FMC Corp. P.O. Box 8 Princeton, NJ 08540	8
Marine Colloids Div. Crockett's Point Rockland, ME 04841	8
*Agricultural Chemical Division 100 Niagara Street Middleport, NY 14105	2
Ford Motor Company The American Road Dearborn, MI 48121	8
Forro Scientific Co. (The) Research Dept. 833 Lincoln St Evanston, IL 60201	8

*Terminated

Category RD-1 Facilities	Reference
*Fort Howard Paper Co. 1919 S. Broadway Green Bay, WI 54305	8
Foster D. Snell, Inc. 800 Dowd Ave. Elizabeth, NJ 07201	8
Foxboro Co. (The) Neponset Ave. Foxboro, MA 02035	8
Fram Corp. 55 Pawtucket Ave. Providence, RI 02916	8
*Frank Morrison & Son Co. 1330 W. 11th St. Cleveland, OH 44113	8
Fulflex Inc. Franklin Street Bristol, RI 02809	1
Fyrnetics Inc. 920 Davis Rd. Elgin, IL 60120	8
Gamewell Corp. (The) 7 Industrial Park Rd. Medway, MA 02053	8,12
Gamma Analysis & Distributing Co. 25050 Ford Rd. Dearborn Heights, MI 48127	8
*Garrett Corp. AiResearch Manufacturing Co. Phoenix, AZ	8
GCA Corp. GCA Technology Div. Burlington Rd. Bedford, MA 01730	8
*General Dynamics Corp. 901 Broad St. Utica, NY	2
Engineered Cast Products Dept. 100 Woodlawn Avenue Elmira, NY 14902	2

*Terminated

Category RD-1 Facilities	Reference
*Flight Propulsion Div. 1000 Western Ave. W. Lynn, MA 01905	8
*Homer Ave. Ashland, MA 01721	8
100 Woodlawn Ave. Pittsfield, MA 02101	8
*Aircraft Engine Group Cincinnati, OH 45215	8
Medical Systems Dept. 4855 W. Electric Ave. Milwaukee, WI 53201	8
Semi-Conductor Products Dept. Building No. 7 - Electronics Park Syracuse, NY 13201	2
*General Electric Company Hotpoint Company Division Chicago, IL	22
*General Foods Corp. Technical Center 555 South Broadway Tarrytown, NY 10951	2
*General Motors Corp. Harrison Radiator Div. Lockport, NY 14091	2
*Rochester Operations 1555 Lyell Avenue Rochester, NY 14606	2
*Tonawanda Motor Plant P. O. Box 21 Buffalo, NY 14240	2
Allison Div. 10th and Grande Ave. Speedway, IN 46224	8
Genii Industries 428 Manington Pl. West Covina, CA 91791	9
Gentex Corp. 10985 Chicago Dr. Zeeland, MI 49464	8

*Terminated

Category RD-1 Facilities	Reference
Geophysical Measurements Corp. Research Dept. 422 Wright Bldg. Tulsa, OK 74103	8
*Georgetown Instruments, Inc. 3520 Prospect St., NW Washington, D.C. 20007	8
Gillette Co. Gillette Park Boston, MA 02106	8
*Globe Union 5757 N. Green Bay Ave. Milwaukee, WI 53225	8
Goodyear Tire & Rubber Co. (The) Technical Div. P.O. Box 628 Piketon, OH 45661	9
*Gould Inc. 40 Gould Center Rd. Rolling Meadows, IL 60008	8
*Gow-Mac Instrument Co. 100 Kings Rd. Madison, NJ 07940	8
*Graham Manufacturing Co., Inc. 4-12 Howard Street Batavia, NY 14020	2
*Grumman Aerospace Corp. Industrial Safety & Hygiene Mail Stop B-33-02 Bethpage, NY 11714	2,22
Great Lakes Carbon Corp. 56th Street and Pine Ave. Niagara Falls, NY 14302	2
*S.J. Groves & Sons Co. P. O. Box 276 Woodbridge, NJ 07095	2
*GTE Sylvania Inc. Johnston St. Seneca Falls, NY 13148	2
Electronic Systems Corp. Eastern Division 77 "A" St. Needham Heights, MA 02194	8

*Terminated

Category RD-1 Facilities	Reference
Towanda, PA 18848	8
*W. 3rd St. Emporium, PA 15834	8
*Old Route 220 Muncy, PA 17756	8
*100 Endicott St. Danvers, MA 01923	8
GTE Laboratories Inc. 40 Sylvan Rd. Waltham, MA 02154	8
*Hamlin, Inc. Lake and Grove Streets Lake Mills, WI 53551	8
Harrell Incorporated 16 Fitch Street E. Norwalk, CT 06855	8
Hawaiian Sugar Planter's Association P.O. Box 1057 Aiea, HI 96701	8
*Hawthorne Center Biochemical Laboratories 18471 Haggerty Road Northville, MI	22
C.I. Hayes, Inc. 800 Wellington Avenue Cranston, RI 02910	1
*Hazeltine Corp. Cuba Hill Rd. Greenlawn, NY 11740	2
Hazleton Environmental Sciences Corp. 1500 Frontage Road Northbrook, IL 60062	8
Hazleton Laboratories Inc. 9200 Leesburg Tpk. Vienna, VA 22180	8
Hercules Inc. Coatings and Specialty Products Dept. Lower Warren St. Glens Falls, NY 12801	2
Wilmington, DE 19899	8

*Terminated

Category RD-1 Facilities	Reference
Hershey Foods Corporation 19 East Chocolate Avenue Hershey, PA 17033	8
*Hoffman Electronics Corporation Research Department 930 Ditner Avenue Evanston, IL	22
Honeywell Inc. 1753 4th Avenue South Minneapolis, MN 55408	8
Chicago & Spring Streets Freeport, IL 61032	8
*10701 Lyndale Avenue South Bloomington, MN 55420	8
600 Second St., N.E. Hopkins, MN 55343	7,8
Parkdale Plaza 1660 South Highway St. Louis Park, MN 55416	8
1500 West Dundee Road Arlington Heights, IL 60004	8
*Hooker Chemicals and Plastics Co. Research and Development Center Box 8 MPO Niagara Falls, NY 14302	2
Howmedica Inc. Corporate R & D Labs Eastern Point Road Groton, CT 06340	8
Hughes Aircraft Company P.O. Box 90515 Building 100/MAI Los Angeles, CA 90009	8
Fred Hutchinson Carrier Research Institute 1124 Columbia St. Seattle, WA	5
*Huyck Corp. Huyck Research Center Washington St. Rensselaer, NY 12144	2

*Terminated

Category RD-1 Facilities	Reference
Index Control Systems 88 Boyd Avenue East Providence, RI 02914	1
*Industrial Biology Research and Test Research Laboratories, Inc. Chemical Departmen 151 East 10th Avenue Conshohocken, PA 19428	22
*Industrial Dynamics Corp. 5135 Elmwood Drive Beech Grove, IN 46107	8
Industrial Dynamics Co., Ltd. 2927 Lomita Blvd. Torrance, CA 90509	9
*Industrial NDT-Company, Inc. 790 Watervliet-Shaker Rd.° Latham, NY 12110	2
*Industrial Nuclear Radiation Consultants Kensington, CT	8
Institute for Research 8330 Westglen Drive Houston, TX 77042	3
Instrumentation Laboratory Inc. 113 Hartwell Avenue Lexington, MA 02173	8
International Business Machines Corp. 1701 North St. Endicott, NY 13760	2
*Neighborhood Rd. Kingston, NY 12401	2
*(IBM) Radiation Effects Dept. Federal Systems Division Oswego, NY 13827	2
*International Minerals & Chemical Co. Research and Development Div. IMC Plaza Rte. 45 and Winchester Rd. Libertyville, IL 60048	8
Internetics Inc. 2275 S. W. Temple Salt Lake City, UT 84115	8

*Terminated

Category RD-1 Facilities	Reference
*Isomet Corporation 103 Bauer Drive Oakland, NJ 07436	8
Isovac Engineering Inc. 932 Grand Central Ave. Glendale, CA 91201	9
*ITEK Corporation 10 Magurie Road Lexington, MA 02173	8
ITT Grinnel Corporation 260 West Exchange Street Providence, RI 02901	8
*JBF Scientific Corporation 2 Jewel Drive Wilmington, MA 01887	8
*Jefferson Research lab, Inc. Charlottesville, VA	8
Johnson and Johnson 501 George Street New Brunswick, NJ 08903	8
*Johnson Service Company 507 East Michigan Street Milwaukee, WI 53201	8
*Jones & Laughlin Steel Corp. Research & Development Dept. Gateway Center, Bldg. # 3 Pittsburgh, PA	22
K. F. Industries Inc. 230 West Dauphin Street Philadelphia, PA 19133	8
Kallestad Laboratories Inc. Research and Development Department 4005 Vernon Avenue Chaska, MN 55318	8
The Kendall Co. Research Center 411 Lake Zurich Rd. Barrington, IL 60010	8
*Kennecott Copper Corporation Ledgemont Laboratory 128 Spring Street Lexington, MA 02173	8

*Terminated

Category RD-1 Facilities	Reference
Kraftco Inc. Research & Development 801 Waukegan Road Glenview, IL 60025	8
*L. C. Company, Inc. 619 Estes Avenue Schaumburg, IL 60172	8,15
Laclede Steel Company Alton, IL 62002	8
Lake Center Industries 111 Market Street Winona, MN 55987	8
Lanal Laboratory Associates Inc. 5188 Fairlawn Drive Fayetteville, NY 13066	2
R. S. Landauer, Jr., and Co. Technical Operations, Inc. Science Rd./Science Park Gleenwood, IL 60425	9
Lambda Research Inc. 7213 Market Place Cincinnati, OH 45216	8
Ledoux and Company 359 Alfred Avenue Teaneck, NJ 07666	8
Leeco Diagnostics Inc. 21174 Bridge Street Southfield, MI 48034	8
Lever Brothers Company 45 River Road Edgewater, NJ 07020	8
*Litton Precision Products Inc. Airtron Division 200 East Hanover Avenue Morris Plains, NJ 07950	8
Lixi Inc. 1438 Brook Drive Downers Grove, IL 60515	8
*The Lubrizol Corporation 29400 Lakeland Blvd. Wickliffe, OH 44092	8

*Terminated

Category RD-1 Facilities	Reference
Lukens Steel Company South 1st Avenue Coatesville, PA 19320	8
*Malcolm Pirnie, Inc. 2 Corporate Park Dr. White Plains, NY 10602	2
P. R. Mallory and Co. Mallory Capacitor Co. 3029 E. Washington St. Indianapolis, IN 46206	8
Manu-tronics Inc. 9115 26th Avenue Kenosha, WI 53140	8
Marine Research Inc. 141 Falmouth Heights Road Falmouth, MA 02540	8
*P. O. Box 1253 Duxbury, MA 02332	8
Mason Research Institute 57 Union Street Worcester, MA 01608	8
Materials Research, Inc. P.O. Box 225 Salt Lake City, UT 84110	9
McGraw-Edison Co. 11131 Adams Road Franksville, WI 53126	8
The Mead Corporation Chillicothe, OH 45601	8
Medx Company 501 South Vermont Street Palatine, IL 60067	8
Meloy Laboratories Inc. 6715 Electronic Drive Springfield, VA 22151	8
Merck & Company Inc. Stonewall Technical Services Stonewall Plant Elkton, VA 22827	8
Merck, Sharp and Dohme Division Rahway, NJ 07065	8

*Terminated

Category RD-1 Facilities	Reference
Micromedic Systems Inc. 102 Witmer Road Horsham, PA 19044	8
*Mid-America Dairymen Inc. 800 W. Tampa Springfield, MO 65805	8,16
Midwest Research Institute North Star Division 10701 Red Circle Drive Minnetonka, MN 55343	8
Miles Laboratories Incorporated Dome Division 400 Morgan Lane West Haven, CT 06516	8
Millipore Corporation Worthington Diagnostics Division Halls Mill Road Freehold, NJ 07728	8
Mirlin Corporation 8 Kane Industrial Drive Hudson, MA 01749	8
*Mobil Oil Corp. 635 Elk St. Buffalo, NY 14240	2
*Mobil Research & Development Corp. Paulsboro Research Laboratory Paulsboro, NJ 08066	8
Mobil Tyco Solar Energy Corporation 16 Hickory Drive Waltham, MA 02154	8
Moleculon Research Corporation 139 Main Street Cambridge, MA 02142	8
Monitor Systems Inc. Salem Industrial Part Rt. 2 Whitehouse, NJ 08833	8
*Mount Desert Island Biological Laboratory Salisbury Cove, ME 04672	8
MSA Research Corporation Evans City, PA 16033	8

*Terminated

Category RD-1 Facilities	Reference
*National Can Corp. 52-08 Grand Ave. Maspeth, NY 11378	2
*National Lead Company Hightstown Laboratories P. O. Box 420 Hightstown, NJ 08520	8
*South Amboy, NJ	8
*National Presto Industries Inc. 3925 North Hastings Way Eau Claire, WI 54701	8
*New England Analytical and Testing 2 Shady Oak Lane Natick, MA 01760	8
New England Small Business Investment New England Tape Company Division 30 Tower St. Hudson, MA 01749	8
R. M. Newell Co., Inc. 5152 Main St. Buffalo, NY 14221	2
*Nite-Site Inc. Rosemount, MN 55068	8
Norcem, Inc. 52-00 2nd Street Long Island City, NY 11101	2
Norman M. Morris Corporation 301 East 57th St. New York, NY 10022	2
Northern Petrochemical Co. P.O. Box 459 Morris, IL 60450	8
*Northrop Corp. Hawthorne, CA	8
Novo Laboratories Inc. 59 Danbury Rd. Wilton, CT 06897	8
*Nuclear Corp. of America; Radioactive Products Inc. Ferndale, MI	8,22

*Terminated

Category RD-1 Facilities	Reference
Nuclear Consulting Services Inc. Research and Field Testing P.O. Box 29151 Columbus, OH 43229	8
Nuclear Data, Inc. Schumberg, IL	15
Nuclear Diagnostics Inc. 575 Robbins Dr. Troy, MI 48084	8
NUS Corporation Curus Wm. Rice Co. 15 Noble Ave. Pittsburgh, PA 15205	8
*Oceanic Institute Makapuu Point Waimanalo, HI 96795	8
*Olin Corp. New Haven, CT 06504	8
Omni-Wave Electronics Corp. Blackburn Industrial Park, PO Gloucester, MA 01930	8
On-Guard Corp. of America 350 Gotham Pky. Carlstadt, NJ 07072	8
Optel Corp. Route 1 and Ridge Rd. Princeton, NJ 08540	8
*Otisca Industries, LTD 911 North Geddes St. Syracuse, NY 13204	2
Overhoff and Associates, Inc. P.O. Box 8091 Cincinnati, OH 45208	8
Owens-Corning Fiberglass Corp. National Bank Bldg. P.O. Box 901 Toledo, OH 43601	8
Owens-Illinois Technical Center 1700 North Westwood Ave. Toledo, OH 43666	8

*Terminated

Category RD-1 Facilities	Reference
*P.A.C.E. Associates 874 Welsh Rd. Maple Glen, PA 19002	8
Pall Corp. 30 Sea Cliff Ave. Glen Cove, NY 11542	2
*Philco Corp. Research Division 'C' & Tioge St. Philadelphia, PA	22
Pennwalt Corp. 900 First Ave. King of Prussia, PA 19406	8
*Pentex Corp. Calcon Hook Rd. Sharon Hill, PA 19079	8
The Perkin-Elmer Corp. 640 Kreag Rd. Pittsford, NY 14534	2
Petrolite Corp. 369 Marshall Ave. St. Louis, MO 63119	8
*Phares Electronics Corp. 340 Lavoy Rd. Erie, MI 48133	8
*Philco-Ford Corp. Ford Rd. Newport Beach, CA 92663	8
Philip Morris USA Research Center P.O. Box 26583 Richmond, VA 23261	8
Philips Roxane Inc. 2621 N. Belt Highway St. Joseph, MO 64502	8
Pineland Center Box C Pownal, ME 04069	8
Pitman-Moore Inc. Research Div. Rt. 579 and Postley Dr. Washington Cross, NJ 08560	8

*Terminated

Category RD-1 Facilities	Reference
Plascal Corp. 361 Eastern Parkway Farmingdale, NY 11735	2
Platina Refining Laboratories 4301 S. Clinton Ave. S. Plainfield, NJ 07080	8
Polyscience Corp. Chemical Div. 6366 Gross Point Rd. Niles, IL 60648	8
Powers Chemco, Inc. Charles St. Glen Cove, NY 11542	2
PPG Industries Inc. P.O. Box 31 Barberton, OH 44203	8
Princeton Gamma-Tech Inc. Route 518 Rocky Hill, NJ 08553	8
*Procter & Gamble Co. (The) 7162 Reading Rd. Cincinnati, OH 45237	8
PSE&G Research Corp. Research & Testing Laboratory 200 Boyden Ave. Maplewood, NJ 07040	8
Qual-X Inc. 4065 N. Leap Rd. Hilliard, OH 43026	8
R I L Electronics Inc. Street Rd. and 2nd Street Pike Southampton, PA 18966	8
Radiation Management Corp. 3505 Market St. Philadelphia, PA	9
Radiation Monitoring Devices Inc. 44 Hunt St. Watertown, MA 02172	8
*Radio Corp. of America Eletronic Components 415 S. Fifth St. Harrison, NJ 07029	8

*Terminated

Category RD-1 Facilities	Reference
Solid State Div. Route 202 Somerville, NJ 08876	8
RAD/IRID Inc. 2212 Georgia Ave. NW Washington, DC 20001	8
Ramsey Corp. Manchester and Weidman Roads Manchester, MO 63166	8
*Ramsey Engineering Co. 1853 W. County Rd. St. Paul, MN 55113	8
Randam Electronics Inc. 3091 Shadycrest Drive Cincinnati, OH 45239	8
*Rasor Associates Inc. Nuclear Engineering Dept. 200 Tatt Rd. Kettering, OH 45429	8
Raytheon Co. Equipment Div. 528 Boston Post Rd. Sudbury, MA 01776	8
465 Centre St. Quincy, MA 02169	8
141 Spring St. Lexington, MA 02173	8
*Microwave & Power Tube Div. Medical Electronics 190 Willow St. Waltham, MA 02154	8
Machlett Laboratories Inc. 70 Ryan St. Stamford, CT 06907	8
*Recra Research, Inc. 111 Wales Ave. Tonawanda, NY 14150	2
*Republic Steel Corp. Electromechanical Research Center 221 East 131 St. Cleveland, OH 44108	8

*Terminated

Category RD-1 Facilities	Reference
Reuter-Stokes, Inc. 18530 S. Miles Pkwy. Cleveland, OH 44128	9
*Revlon Research Center, Inc. 945 Zaraga Ave. Bronx, NY 10473	2
*Metallurgical Research Division 401 E. Canal St. Richmond, VA 23218	8
Rhodia, Inc. Agricultural Div. Black Horse Lane P.O. Box 125 Monmouth Junction, NJ 08852	8
Rhone Poulenc Inc. Hess and Clark Div. 7th and Orange Sts. Ashland, OH 44805	8
*The Richardson Company Chemprene Division 570 Fishkill Avenue Beacon, NY 12508	2
Richardson-Merrell Inc. Merrell-National Laboratories 110 E. Amity Rd. Cincinnati, OH 45215	8
Robert H. Wager Co. Inc. Passaic Ave. Chatham, NJ 07928	8
Rockefeller Institute New York, NY	8
Rohm and Haas Co. Research Laboratories Norristown and McKean Rd. Spring House, PA 11477	8
Rosenthal Technik, North America, Inc. 100 Niantic Avenue Providence, RI 02907	1
RS Holding Inc. Electronic-Nuclear Testing Dept. 18530 S. Miles Pky. Cleveland, OH 44128	8

*Terminated

Category RD-1 Facilities	Reference
Sandoz Inc. Route 10 East Hanover, NJ 07936	8
Sangamo Weston Inc. Weston Instruments Division 614 Frelinghuysen Ave. Newark, NJ 07114	8
Schering Corp. 60 Orange St. Bloomfield, NJ 07003	8
Schlumberger Technology Corp. Schlumberger-Doll Research Center Old Quarry Rd. Ridgefield, CT 06877	8,9
*Schlumberger Well Surveying Corp. 5000 Gulf Freeway Houston, TX	22
Scientific Associates Inc. 6200 S. Lindbergh Blvd. St. Louis, MO 63123	8
*SCM Corp. Glidden Durkee Div. 900 Union Commerce Bldg. Cleveland, OH 44155	8
Scott-Brass, Inc. 1637 Elmwood Avenue Cranston, RI 02910	1
Joseph E. Seagram & Sons Inc. Mill & Main Streets Lawrenceburg, IN 47025	8
Searle Diagnostic, Inc. Buchler Instrument Div. 1327 16th St. Fort Lee, NJ 07024	8
G. D. Searle & Co. Research & Development Div. P. O. BOX 5110 Chicago, IL 60680	8
SERA Inc. 3728-B Olentangy River Rd. Columbus, OH 43214	8

*Terminated

Category RD-1 Facilities	Reference
Shell Oil Co. P.O. Box 262 Wood River, IL 62095	8
P.O. Box 100 Deer Park, TX 77536	8
Sheller-Globe Corp. Victoreen, Inc. 10101 Woodland Ave. Cleveland, OH 44104	9
Signetics Corp. 1275 S. 800 E. Orem, UT 84057	8
Simplex Time Recorder Co. 26 S. Lincoln St. Gardner, MA 01440	8
Singer Co. (The) Kearfott Div. 1150 McBride Ave. Little Falls, NJ 07424	8
*SKF Industries Inc. Engineering & Research Center King of Prussia Industrial Park 1100 First Ave. King of Prussia, PA 19406	8
*Smith, Miller, and Patch, Inc. 401 Joyce Kilmer Ave. New Brunswick, NJ 08902	8
Southern Railroad Co. Research & Tests Laboratory 409 S. Henry St. Alexandria, VA 22313	8
Southwestern Institute of Forensic Sciences at Dallas 5230 Medical Center Dr. P. O. Box 35720 Dallas, TX 75235	3
*Standard Brands, Inc. The Fleischmann Laboratories Betts Ave. Stamford, CT 06904	8

*Terminated

Category RD-1 Facilities	Reference
Stauffer Chemical Co. Environmental Health Center 400 Farmington Ave. Farmington, CT 06032	8
*Steiner American Corp. 505 E. South Temple Salt Lake City, UT 84102	8
Stepan Chemical Co. Maywood Div. 100 W. Hunter Ave. Maywood, NJ 07607	8
*Strathmore Paper Co. Front St. W. Springfield, MA 01089	8
Sun Chemical Corporation 441 Tompkins Ave. Rosebank, NY 10305	2
Sun Co. Inc. Applied Research Laboratories 100 Matsonford Road Radnor, PA 19087	8,22
Sunbeam Corp. Sunbeam Appliance Co. Div. 2001 S. York Rd. Oak Brook, IL 60521	8
Oster Div. 5055 N. Lydell Ave. Milwaukee, WI 53217	8
*Suntac Nuclear Corp. 1528 Walnut St. Philadelphia, PA 19102	8
*Sylvania Electric Products Sylcor Div. Hicksville, NY	23
Syntech, Inc. 169 Mill St. Cranston, RI 02905	1
Syntex Agribusiness Inc. Nutrition & Chemical Div. P.O. Box 1246 SSS Springfield, MO 65805	8

*Terminated

Category RD-1 Facilities	Reference
T.M. Smith Tool Co. 360 Hubbard Ave. Mt. Clemens, MI 48043	8
Talley Industries Inc. Research Center 58 Progress Dr. Stamford, CT 06902	8
Tech/Ops Inc. 40 North Ave. Burlington, MA 01803	7
Teledyne Inc. 1901 Ave of the Stars Los Angeles, CA 90067	9
Tennelec Inc. 601 Oak Ridge Turnpike Oak Ridge, TN 37830	9
Texas Institute for Rehabilitation and Research 1333 Moursund Houston, TX 77025	3
Thermo-Systems Inc. P.O. Box 3394 St. Paul, MN 55165	8
Thomas J. Lipton, Inc. 800 Sylvan Ave. Englewood Cliffs, NJ 07632	8
*Time Computer Inc. 901 Columbia Ave. Lancaster, PA 17604	8
Tracor Inc. Tracor Northern 2551 W. Beltline Hwy. Middleton, WI 53562	8,9
Travenol Laboratories Inc. 6301 Lincoln Ave. Morton Grove, IL 60053	8
Fenwal Laboratories Div. Wilson Rd. & Route 120 Round Lake, IL 60073	2
Trek, Inc. 1674 Quaker Rd. Barker, NY 14012	2

*Terminated

Category RD-1 Facilities	Reference
*TRW Inc. Philadelphia Laboratories 401 N. Broad St. Philadelphia, PA 19108	8
Ultra Scientific 1 Main St. Hope, RI 02831	1
Underwriters' Laboratories Inc. 207 E. Ohio St. Chicago, IL 60611	8
Union Carbide P.O. Box 8361 S. Charleston, WV 25303	8
*137 47th St. Niagara Falls, NY 14302	2
Uniroyal Inc. 74 Amity Road Bethany, CT 06525	8
Uniroyal Tire Co. Corporate R&D Oxford Management & Research Center Middlebury, CT 06749	8
United Technologies Corp. Pratt and Whitney Aircraft Group 400 Main St. East Hartford, CT 06108	8
Unitrode Corp. 580 Pleasant St. Watertown, MA 02172	8
Universal Foods Corp. Red Star Yeast Div. 325 N. 27th St. Milwaukee, WI 53208	8
Universal Match Co. Ferguson, MD	22
Universal Oil Products Co. 30 Algonquin Rd. Des Plaines, IL 60016	8
Varian Associates BOMAC Division 8 Salem Rd. Beverly, MA 01915	8

*Terminated

Category RD-1 Facilities	Reference
Victoreen, Inc. Nuclear Associates 100 Voice Road Carte Place, NY 11514	9,24
Vitro Corp. of America West Orange, NJ	8
Salt Lake City, UT	8
Walter Kidde & Co., Inc. Fenwal Div. 400 Main St. Ashland, MA 01721	8
Wapora Inc. Rural Route 2 Charleston, IL 61920	8
Waupaca Foundry Inc. 406 N. Division St. Waupaca, WI 54981	8
Western Electric Co., Inc. Hawthorne Station Chicago, IL 60623	8
Westreco Inc. 809 Collins Ave. Marysville, OH 43040	8
Wheaton Glass Co. 3rd and "G" Sts. Millville, NJ 08332	8
Whirlpool Corp. Research and Engineering Center Monte Rd. Benton Harbor, MI 49022	8
York Research Corp. One Research Drive Stamford, CT 06906	8
*Zenith Radio Corp. 1000 Milwaukee Ave. Glenview, IL 60025	8
*2407 W. North Ave. Melrose Park, IL 60160	8
Zivic-Miller Laboratories, Inc. 3848 Hieber Rd. Allison Park, PA 15101	8

*Terminated

Appendix B
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